

985,929



PATENT SPECIFICATION

DRAWINGS ATTACHED

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985,929

Date of Application and filing Complete Specification: March 26, 1962.

No. 4506/61. 11506/62

Complete Specification Published: March 10, 1965.

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Index at acceptance:—G5 R(43D1Y, 43DY, 43Y, 44B3, 44B4U, 44B4Y, 44BY, 44C2A, 44C2B, 44C2C, 44C2Y, 44CY, 44D1A, 44D1D, 44D1G1, 44D1GY, 44D1U, 44D1Y, 44D2C, 44D2Y, 44D3B, 44D3Y, 44D4B, 44D4C, 44D4D, 44D4U, 44D4Y, 44D5FU, 44D5FY, 44D5Y, 44DY, 44J, 44Y, 45F1, 45FY, 45Y, 46S)

Int. Cl.:—G 10 j

COMPLETE SPECIFICATION

Improvements in or relating to Magnetic Recorders

We, AKAI ELECTRIC COMPANY LIMITED, of No. 883, 3-chome, Kohjiya-cho, Ohta-ku, Tokyo, Japan, a Body Corporate organised under the laws of Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to magnetic recorders of the general type employing elongate magnetic recording media such as magnetic tapes and the like. More specifically the invention relates to a magnetic head assembly in such a magnetic recorder, which assembly is adapted for utilising the high frequency biasing technique and in which a signal recording head and a separate high frequency biasing head are used, which are adapted for being energised independently.

20 Generally speaking, the record head assembly in magnetic tape recorders in current use comprises a combined head for both signal recording and high frequency biasing, the head having a single magnetic core. In such a head assembly, however, selection of the relative operative positions of the recording and biasing fields is naturally highly restricted. From this reason, it has already been proposed to position two kinds of heads in physically separated relation, whereby to provide a selected physical and electromagnetic interrelationship between the two heads, as well as a predetermined physical relation between the heads and the magnetic tape, for the purpose of improving the recording characteristics of the head assembly.

40 It is commonly known that with the high frequency biasing technique, the higher the signal frequency to be recorded, the more difficult it is to satisfactorily record the signal, this being due to the so-called "high frequency fall-off." More specifically, higher frequency

signals, although actually recorded on the tape during recording operation of the machine, are still subjected to the influence of the high frequency biasing field, and thus, in practice, are substantially weakened or even completely erased. On account of this phenomenon, it is difficult to record a signal frequency higher than about 10,000 c.p.s. under usual operative conditions.

Various attempts have been made to solve the above problem and to improve the high frequency response. A proposal for this purpose is, for instance, to employ an asymmetrical configuration of the high frequency biasing head so as to produce an abruptly shaped magnetizing field from the gap thereof, thereby minimizing the magnetic fluxes otherwise developing at least in the trailing region of the field, when seen in the advancing direction of the tape. This results, however, in a highly complicated head assembly yet leads to only a small improvement.

It is therefore an object of the present invention to provide a magnetic head assembly capable of recording signal frequencies including those ranging as high as 20,000—80,000 c.p.s. or higher.

In the tape recording art, considerable efforts have been made to decrease the tape running speed without sacrificing the recording performance. The difficulty as commonly met with in this respect is partially attributable to the existence of the disadvantageous trailing high frequency magnetizing field above referred to. It has now been found that by making such trailing field substantially ineffective upon the already recorded tape, the tape speed can be decreased to, say, one half the conventionally employed value, yet with same or even superior recording performance.

From experiments it has now been ascertained that for obtaining a superior recording performance in a tape recording machine using

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separate recording and biasing heads, a predetermined precise distance should be maintained between both heads during the recording operation so as to subject the moving tape to the premagnetizing fluxes under optimum conditions, whereby to provide the recording tape with maximum sensitivity and the recorded signals with minimum distortion. The two heads may have their gaps arranged opposite to each other, although better results can be obtained with a slightly inclined arrangement of these heads relative to each other. Since the tape must be subjected to a full pre-magnetizing effect within the leading region of the high frequency biasing field in advance of the gap, while the gap of the recording head must have a shortest possible length, the gap length of the biasing head should be considerably larger than that of the recording head, especially when the latter is also used as the playback head. The ratio between the gap lengths may preferably be between 2 and 500. It has been further found desirable to guide the moving tape, while recording, through the trailing region of the pre-magnetizing field by the shortest possible passage length by providing suitable tape guide means for this purpose. The guide means comprise preferably part of the leading guide surface of the record head, in combination with a plurality of tape guide posts arranged at separated intervals. Provision should also be made to mechanically separate one of the two magnetic heads from the other at least during playback, since although during playback the biasing head is electrically inoperative, hum voltages may otherwise be induced in the playback head, if it is also used as the recording head, by external unbalanced magnetic fields frequently caused by transformers and the like arranged in the machine.

The head separation above referred to may be effected by a pivotally movable member, upon which the biasing head is adjustably mounted and which is linked to a conventional record/playback control knob mounted on the machine.

The distance between the two heads during recording may be fixed to a value, for instance, between about 0.1 and 1.0 millimeters, although these specified figures are non-limitative and may vary depending upon a number of parameters such as the ampere turns employed for the biasing head, the kind of tape used, the length of the gap in the heads, and so on. It is advisable to provide the movable member with an adjustable, spring-loaded stop to maintain a preselected distance between the heads. The movable member is preferably a pivoted plate, although it can be in the form of a linearly reciprocable member.

In order to establish an optimal operative position of the biasing head relative to the recording head and the tape, it is desirable to provide the biasing head with a fine adjust-

ing means so as to enable alteration as required of the mounting angle of the head in every direction, and of the relative longitudinal position thereof relative to the recording head, as seen in the tape running direction.

In its broadest aspect, the invention consists in a magnetic recorder comprising a head assembly adapted to co-operate with an elongate flexible magnetic recording medium, the assembly comprising an erase head, a recording head, and a high frequency biasing head disposed opposite to the recording head, the recording head and the biasing head each having a core with a gap therein, the core gap of the biasing head being relatively long in comparison with that of the recording head, means being provided for maintaining the biasing head at a pre-selected minimum distance from the recording head, means being provided for guiding the magnetic recording medium in such a manner that it passes through the trailing region of a high frequency biasing field emanating from the gap of the biasing head, at a zone in the said field which is spaced apart from the biasing head core.

It will be appreciated that if the magnetic recording medium were passed over the biasing head and in contact therewith, the medium would pass through substantially the entire extent of the trailing region of the high frequency bias field and the de-magnetizing influence of the said trailing region on the recorded signal would be a maximum. By passing the magnetic recording medium through the said trailing region at a zone thereof which is spaced apart from the biasing head core, the magnetic recording medium does not pass through the entire extent of the said trailing region of the field, and the de-magnetizing influence is reduced.

In order to make the invention clearly understood, reference will now be made to the accompanying drawings which are given by way of example and in which:—

Fig. 1—A is a diagrammatic plan view showing the conventional recording technique, in which a magnetic tape shown diagrammatically by a thick chain line is slidingly guided across and in contact with a high frequency biasing head;

Fig. 1—B is a similar diagrammatic plan view, illustrating the principle of the invention, wherein a high frequency biasing head and a recording head are arranged opposite to each other at a predetermined spacing, and the tape is separated from the biasing head and guided across and in contact with the recording head;

Fig. 1—C is a view similar to Fig. 1—B, in which, however, the two kinds of heads are arranged somewhat off-set;

Fig. 2—A is a diagrammatic view illustrative of effects as encountered in the use of the conventional tape and head arrangement shown in Fig. 1—A.

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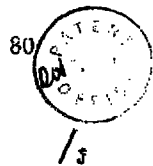


Fig. 2—B is a view similar to Fig. 2—A, wherein, however, the tape is so guided that it travels within the trailing region of the high frequency biasing field along a short transit path;

Fig. 3 is a top plan view of a magnetic head assembly, a head manipulating knob and a cover being omitted for the sake of clarity;

Fig. 4 is a front elevational view of the head assembly, showing the knob and the cover;

Fig. 5 is a side view of the head assembly, when seen from the left hand side of Fig. 3;

Fig. 6 is an enlarged detail view of an adjustable, spring-loaded stop means employed;

Fig. 7 is a simplified elevational view of the head assembly, illustrative mainly of stop pads attached fixedly to one of the heads, in order to establish a predetermined optimum distance between the heads when in operation, said pads being employable in place of the said adjustable stop means;

Fig. 8 is a somewhat diagrammatic representation of a mechanical linkage, by which the head separating operation is carried into effect in synchronism with the operation of a record/playback control knob;

Fig. 9 is a front view of a fine head-positioning mechanism attached to the biasing head; and

Fig. 10 is a top plan view thereof.

Now, referring to the attached drawings, especially Figs. 1—A and 2—A thereof, 10 denotes a high frequency biasing head, of which the conventional energizing coils have been omitted for the sake of clarity, an elongate magnetic record medium, such as a magnetic tape, being indicated by a chain line, the arrow showing the travelling direction of the tape. A conventional slit gap 12 is formed in the head, so that when the coils are energized a high frequency biasing field 13 is developed, the peak of which is in radial registration with the centre of the gap 12. For better understanding, this field 13 can be imaginatively divided into two regions, the leading region in advance of the gap and the trailing region in the rear thereof. The configuration of the field bears a resemblance to that of a normal error curve, with its flanks presenting gradually decreasing included angles with the front surface of the head as the distances from the gap increase. The tape during its movement is subjected to pre-magnetizing under the influence of magnetic fluxes within the leading region. Although not shown in Figs. 1—A and 2—A, a recording head may be integral with the biasing head, or alternatively a combined record/playback head is arranged opposite to the biasing head so that the slit gap 12 is opposite to that of the combined head, so that the running tape 11 is subjected to magnetic recording at or in the proximity of the gap 12. However, as

was mentioned hereinbefore, the thus recorded signals are erased to a greater or lesser degree by the action of high frequency magnetic fluxes having gradually decreasing amplitude while the tape is further travelling within the trailing region of the biasing field. This effect is more predominant upon higher frequency recorded signals, so that it is frequently called "fall-off" in high frequency response, as was briefly referred to hereinbefore. The longer the effective length G between the opposite extremities of the flanks of the field 13, the more appreciable will be the disadvantageous erasing effect.

More specifically described with reference to Fig. 2—A the above-mentioned effect upon any selected point on the tape can be more clearly understood. The alternations of magnetic fluxes, to which a point on the tape is exposed while it travels across the biasing head, are diagrammatically illustrated by a chain line drawn within the illustrated high frequency magnetizing field enclosed by the line 13. It will be clear that a selected point on the tape will be subjected to the action of magnetic fluxes having increasing amplitudes in the leading region, while the same point will be acted upon by magnetic fluxes having decreasing amplitudes within the trailing region of the magnetizing field, which phenomenon can be easily understood by reference to the upper diagram in Fig. 2—A. It should, however, be noted that the relative dimensions of the head, the magnetizing field and thus the amplitudes and the number of alternations of the magnetic fluxes are merely illustrative, for showing the characteristic features of the magnetization effects of the biasing field, and that the drawing has been plotted as if the lower envelope of the biasing field coincides with the tape guide surface of the biasing head, although in practice the shape of the magnetizing field is more complicated, especially in the zone of the gap, as is well known to those skilled in the art. In practice, any selected point on the tape is subjected to the influence of the oscillating magnetizing fluxes substantially in a symmetrical shape, as shown in the upper diagram of Fig. 2—A in a highly simplified manner. In this case, numerals 1, 2 . . . 5 show the numerical order of alternations of the magnetizing fluxes having influence upon any selected point on the tape while it travels through the trailing region at the rear of gap 12. Thus, the tape is subjected to the action of five alternations of the flux. If the tape should be led through the trailing region so as to minimize the number of the said alternations influencing the tape, or more specially influencing the already recorded signals thereupon, a considerable improvement in the recording technique can be realized. Thus, if the tape is led so as to make an abrupt change in its travelling direction in the trailing region,



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selected

thereby establishing a shortest possible passage length for the tape in that region, as shown in the lower part of Fig. 2—B, the desired optimal recording could be realised. Thus, in this case, the afore-mentioned number of alternations can be reduced to only two, as shown by way of example in the upper part of Fig. 2—B. In practice, however, difficulty is met with in guiding the tape in the above-mentioned way, because the tape must make an abrupt bend at a point very near to the biasing head gap.

In one form of the present invention, as illustrated in principle in Fig. 1—B, the high frequency biasing head 10 is positioned opposite to and at a predetermined distance D from a recording head 14, which may be of the conventional design, with the gaps 12 and 15 of these heads positioned in line with each other as shown. The distance D is selected to be much larger than the necessary minimum for loading the tape 11 into its proper operative position as shown, or in removing it therefrom. With a given set-up of the record head assembly and given ampere turns of the biasing head, the distance D should be kept at an optimal value for the realization of the maximum sensitivity of the tape and the minimum distortion of the recorded signals. It depends upon the ampere turns of the biasing head, and varies, as has been experimentally determined, substantially with variation in the ampere turns. The said distance varies also with variation in the gap length in the biasing head. As the most simple way to determine this distance, the biasing head is gradually moved relatively to the co-operating record head, while repeatedly carrying out recording and play-back. This distance can be set to a certain definite value by experiment, more specifically by determining the optimum overall response in the desired signal frequency range.

Once the distance D has been fixed, the tape outlet angle θ , as illustrated in Figs. 1—B and 2—B, must be determined. In this case, also, the trial-and-error method similar to that employed for determination of the distance D can be advantageously employed. As an example, the distance D may be 0.5 mm and the tape outlet angle may be 30 degrees. In this way, the optimum effective width of the high frequency biasing field g can be automatically determined, which is considerably smaller than the afore-mentioned distance G .

In the head assembly finely adjustable means for correct determination of the said distance is preferably provided for shifting precisely and continuously one of the two heads, preferably the biasing head, relatively to the other. A preferred embodiment for this purpose shall be described in detail hereinafter with reference to Figs. 3—6.

In the head assembly, in contrast to the arrangement basically illustrated in Figs.

1—A, 2—A and 2—B the tape in the neighbourhood of the biasing head gap is guided directly by means of the recording head itself with the magnetizable layer of the tape kept in sliding contact therewith, so that upon proper adjustment in the aforementioned manner, the foremost extremity of the recording head gap is positioned at the optimum point within the biasing field to provide the tape with the already mentioned optimal operating conditions.

The recording head itself may form one of the main constituents for guiding the tape while travelling under the above mentioned optimal operative conditions, especially at a predetermined distance from the biasing head gap and at an optimal outlet angle so as to lead the tape along its shortest possible passage within the trailing region of the biasing field. With the symmetrical arrangement of the two heads as shown in Fig. 1—B, such a simple arrangement in which the tape is guided along the leading tape guide surface of the recording head within a reasonable range, may substantially satisfy the desired requirements. The head may be of circular cylindrical configuration in view of the ease of finish grinding, or it may be finished to a non-circular cylindrical form by form-grinding. In the latter case, the head can be shaped so as to provide an optimal configuration to meet the above-mentioned requirements. In such a case, the optimal tape outlet angle should be accurately determined and experimental determination is also highly recommendable in consideration of the fact that the marginal configuration of the high frequency biasing field, in practice, cannot be sharply defined, so that it is quite impossible to determine the outlet angle by graphical solution. The trial-and-error procedure as already described is therefore recommended. If a machine designer selects a signal frequency range of 1 to 10 kc, which correspond to the medium and the high regions of audio frequency signals, signals having these extreme frequencies are recorded and played back while varying the tape outlet angle. If the designer obtains highest possible outputs at these marginal signal frequencies by trial-and-error, he may choose such outlet angle to be the optimal.

In a modified head arrangement, shown in Fig. 1—C, the two heads are arranged in an asymmetrical relative position. In fact, such an arrangement of the two heads is advisable, on account of its superior recording performance. This could be attributable to the fact that with such an inclined arrangement of the heads the recorded tape may pass through the biasing field trailing region with a still shorter passage than that obtainable with the aforementioned symmetrical arrangement.

Numerals 46, 47 and 48 in Fig. 3 designate auxiliary tape guide posts acting for this purpose in co-operation with part of the tape

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guiding surface of the recording head.

The distance between the two heads, the position of the point in the middle of the biasing field, through which the tape must be led, and the tape outlet angle in this case, can be determined and kept at their optimal values, in an experimental way similar to that already described.

Referring further to Figs. 3—10, a more specific embodiment embodying the above described basic principles of the invention shall be now explained hereinbelow.

In this embodiment, which is illustrated in its operative position, numeral 20 designates a base plate of the head assembly which is fixedly mounted on a deck, not shown, of a magnetic tape recorder by means of suitable fixing means such as bolts and nuts, also not shown. On the base 20, a cover 21, having a substantially dome-shaped configuration, yet being open at the front thereof, is detachably mounted by means of a plurality of bolts 22, one of which is shown in Fig. 5. Also on the base 20, a table 23 mounting fixedly thereon an erase head 24 of the conventional type is mounted vertically slidably in response to manual operation of a control knob 25. The erase head is shown in its lowest possible position. The purpose of the vertically slidable arrangement of the head mount is to enable operation of the head assembly under various recording operations, such as multi-track monaural, and binaural recording, but this feature does not in any way constitute part of the invention, so that more detail description thereof has been omitted. The movable table 23 mounts a pivotal mounting member 27 by means of a pivot 26 as shown, the member 27 being pivotally movable in a horizontal plane. On the pivotally arranged mounting member 27 a high frequency biasing head 29 is mounted by means of a fine adjusting mechanism 28, which shall be described in greater detail hereinafter with reference to Figs 9 and 10. Numeral 30 designates a recording head mounted fixedly on the base 20 either in a symmetrical manner or in an asymmetrical way, as the case may be, as already explained with reference to Fig. 1—B and 1—C. respectively. Since the said distance D is in practice very small, in Fig. 3 the two heads are shown as if they both touch the magnetic tape 11, which is illustrated diagrammatically by a chain line. In practice, however, the two heads are kept separated by the predetermined distance D from each other under their operative conditions, as has already been described. A tension spring 31 is provided between the mounting member 27 and the base 20, thereby urging the biasing head towards the recording head. Adjustable stop means are provided which comprise a fine pitch screw 32 having its inner end in contact with a stationary stop 33, which is formed on the base plate 20. Thus, it will be clear that by turning the ad-

justing screw 32 in one direction or the other, the member 27 is caused to turn in the clockwise direction or in the anti-clockwise direction when seen in Fig. 3 and that in this way the distance between the two heads can be precisely adjusted as desired to provide the desired improved recording performance. It will be further noted, that when the distance D has been determined by the already described procedure, the distance D is the same for identical machines so that it is not always necessary to fit the fine adjusting mechanism to all machines. The head assembly, when non-adjustable, can be arranged according to a modification as shown in Fig. 7, in which two buffer elements 34 and 35, preferably made of a suitable, slightly resilient material, such as hard rubber, are employed to limit the distance between the two heads 29 and 30 to a predetermined value. A space formed between these elements serves in this case for guidance of the magnetic tape 11.

The above described fine adjustment mechanism is illustrated in Figs. 9 and 10, in greater detail. The pivotally arranged member 27 has fixedly mounted thereon a supporting member 40 of angular form and the biasing head 29 is adjustably mounted by means of three adjusting screws 41, 42, 43 arranged in a triangle, as seen in Fig. 10. On each of the screws 41, 42, 43, a coil spring 44 is provided and mounted under compression between the head 29 and the support 40. Between the adjusting screws 41 and 43, there is provided a pivot-like supporting pin 45 screwed through the vertical wall of the supporting member 40. It will thus be clear that by adjusting any one or two of the screws 41, 42, 43, the inclination of the head 29 in any desired direction can be properly adjusted. When all three screws and the pin 45 are screwed-in, the head 29 will be correspondingly brought nearer to the stationary support 40, and vice versa, thereby providing the possibility of adjusting the relative longitudinal position of both heads 29 and 30, seen from the running direction of the tape, so as to bring these heads into registration with each other, or into a predetermined offset relation therebetween.

When a record/playback control knob 50 (Fig. 8) is moved into its "STOP"-position, a follower roller 53 engages the lobe of a cam 52 connected integrally with a stem 51 of the knob, so that the pivot end of a lever 54 is moved into its lowermost position as seen in Fig. 8. This anti-clockwise rotation of the lever 54 about a pivot pin 55, which is between the two ends of said lever, is transmitted through a connecting rod 56 to the already described pivotable member 27, so as to move the biasing head 29 away from the recording head 30 into the separated position.

When the knob 50 is moved into the "PLAY"-position, the follower roller 53 still



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engages the lobe of the cam 52 so that the heads 29 and 31 are kept in their separated position.

5 However, when the knob is moved into the position "REC" the follower roller rolls down from the cam lobe and the corresponding motion is transmitted to the pivotable head mount 27 in the reverse sense, so that the biasing head is brought into its co-operative position relative to the recording head. Under these conditions, the head assembly can effectively function as in the previously described manner. By adjustment of the adjusting screw 32, the head mount 27 and thus the biasing head can be adjusted in its separating distance from the record head, as in the manner previously described.

WHAT WE CLAIM IS:—

20 1. A magnetic recorder comprising a head assembly adapted to co-operate with an elongate flexible magnetic recording medium, the assembly comprising an erase head, a recording head, and a high frequency biasing head disposed opposite to the recording head, the recording head and the biasing head each having a core with a gap therein, the core gap of the biasing head being relatively long in comparison with that of the recording head, means being provided for maintaining the biasing head at a preselected minimum distance from the recording head, means being provided for guiding the magnetic recording medium in such a manner that it passes through the trailing region of a high frequency biasing field emanating from the gap of the biasing head, at a zone in the said field which is spaced apart from the biasing head core.

35 2. A magnetic recorder as claimed in claim 1, wherein the recording head gap and the biasing head gap are disposed opposite each other in such a manner that a plane passing perpendicularly through one gap also passes

perpendicularly through the other gap, a part of the tape guide surface of the recording head and a guide post positioned at a distance therefrom serving as the said guiding means for the magnetic medium. 45

3. A magnetic recorder as claimed in claim 1, wherein the recording head gap and the biasing head gap are disposed generally opposite each other in such a manner that a plane passing perpendicularly through the recording head gap and a plane passing perpendicularly through the biasing head gap intersect, a part of the tape guide surface of the recording head and a guide post positioned at a distance therefrom serving as the said guiding means for the magnetic medium. 50 55

4. A magnetic recorder as claimed in claim 1, 2 or 3, wherein the biasing head is mounted on a plate pivotally mounted relatively to the recording head, the arrangement of the plate being such that by manipulation of the plate the biasing head can be moved so as to be further spaced from the recording head than by the said minimum distance. 60 65

5. A magnetic recorder as claimed in claim 4, wherein a link mechanism operatively connected between a manually operable record/playback knob and the mounting plate is provided for separating the biasing head from the recording head by more than the said minimum distance when the knob is set to a function other than record. 70

6. A magnetic recorder comprising a head assembly constructed, arranged and adapted to operate substantially as hereinbefore described with reference to and as illustrated in Figs. 3 to 8 of the accompanying drawings. 75

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5. A magnetic recorder as claimed in claim 4, wherein a link mechanism operatively connected between a manually operable record/playback knob and the mounting plate is provided for separating the biasing head from the recording head by more than the said minimum distance when the knob is set to a function other than record. 70

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