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Cassette Player with Electronic Tuner

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In recent years car audio market's needs have been changing.
In other words, the conventional type component car stereo, leading the medium/high grade car audio market, has been on the decline, while the functionally combined component car stereo or medium/high grade cassette player with electronic tuner compatible with the upgraded system has taken the lead.
The reason is that the compact disc has spread besides AM/FM broadcast and compact cassette which are conventional source and it has become impossible to upgrade the system in double DIN (100mm height) space for the conventional component car stereo.
While promoting the development of such a functionally combined component car stereo, we, in this June, put on the market the cassette player with electronic tuner QZ-770 following the popular QZ-650 and QZ-670 which were released last year.
This new player, QZ-770 is compatible with the upgraded system for CD player and graphic equalizer and adapts various techniques that transcends the tuner-built-in system concept. Particularly its total quality is high evaluated.

1. Introduction

For these several years, the market in Japan for the cassette player with an electronic tuner has expanded rapidly, while the market for component type car stereo has declined. We also released the QZ-650 and QZ-670 Cassette Tape Players with an Electronic Tuner in 1986 and gained greatly public favor. The QZ-770 we put on the market recently aims at "the cassette tape player with an electronic tuner surpassing the component car stereo" that can be fit for high grade sound quality orientation of the cassette tape player with an electronic tuner and can also be expanded.

For this reason, the QZ-770 incorporates an electronic tuner, microprocessor-controlled tape deck, and a high power amplifier to drive four loudspeakers thus pursuing basic performance in one DIN size, carefully selecting the functions of the cassette tape player with an electronic tuner, and is made superior to the conventional type component stereo in both functions and sound quality.

This paper describes the purpose of the QZ-770 development and outlines its design below.

2. Purpose of devolopment

The QZ-770 was developed to be the advanced model of the QZ-650 and QZ-670 Cassette Players with an Electronic Tuner that were released in June 1986. The purpose is to expand the series of the cassette players with an electronic tuner and improve the brand on the market.

Consequently, the QZ-770 was developed to gain the favor of fans of the cassette player with an electronic tuner rather than the favor of the conventional type component stereo user. In other words, the QZ-770 was developed based on the basic product concept 'what is the true Hi-Fi car stereo?' that is truly desired by the hi-fi-phile. The details are described below.

2.1 Added expandability

The purpose of the QZ-770 is to set up a system that matches each of various users so as to satisfy the requirements of the users more finely. The QZ-770 must have such ample functions that fans who are sensitive to sound can set up their system, for example, the connection of a compact disc player

(CDP) or a graphic equalizer and connection of an external higher-power amplifier.

2.2 Ensuring high quality feeling in design and operation

The QZ-770 has been provided with a feeling of high quality resulting from well considered design including surface finish of the respective parts to help the expression of good sound and reliability. Also, in operation, the QZ-770 aims at a feeling of higher grade such as use of color VFD (vacuum fluorescent display) and OPTI-MI buttons in addition to the pursuit of an feeling of precision.

Table 1. Specifications (QZ-770)

Item		Description
Electronic tuner		
FM	Frequency range	76.0 – 90.0 MHz
	Usable sensitivity	10.8 dBf (New IHF)
	Search sensitivity	DX 27 dBf LOCAL 52 dBf
	Frequency characteristic	30 Hz – 15 kHz
	Stereo separation	40 dB
	Noise blanker effect	30 dBf or more (MONO)
AM	Frequency range	522 – 1629 kHz
	Usable sensitivity	22 μV (S/N 20 dB)
	Search sensitivity	DX 40 μV LOCAL 700 μV
Cassette tape deck		
	Track type	4-track 2-channel
	S/N	NR-OFF 55 dB (IHF-A) NR-ON 64 dB (IHF-A)
	Crosstalk	56 dB
	Stereo separation	40 dB
Amplifier		
	Tone control	Bass ±10 dB (100 Hz) Treble ±10 dB (10 kHz)
	Loudness	+ 5 dB (100 Hz) + 7 dB (10 kHz)
	Output	20 W × 4

2.3 Improved basic performance

The radio receiving performance and the basic deck characteristics were restudied completely from a concept of 'Better Hi-Fi playback with better stability.' As a result, the QZ-770 has introduced an FM PLL detector and a microprocessor-controlled tape-deck.

2.4 Upgrading sound

By pursuing the sound quality, the QZ-770 will be appreciated by users for the good sound rather than the function.

In other words, the purposes of the QZ-770 were to obtain a total of 80 W of overwhelming power and clear sound at low distortion in a car even when the QZ-770 is accommodated in one DIN size by providing four built-in 20 W high-power amplifiers with improved circuitry.

To achieve these purposes, we developed and designed many items.

3. Design outline

3.1 System expandability

Figure 1 shows the QZ-770 system block diagrams.

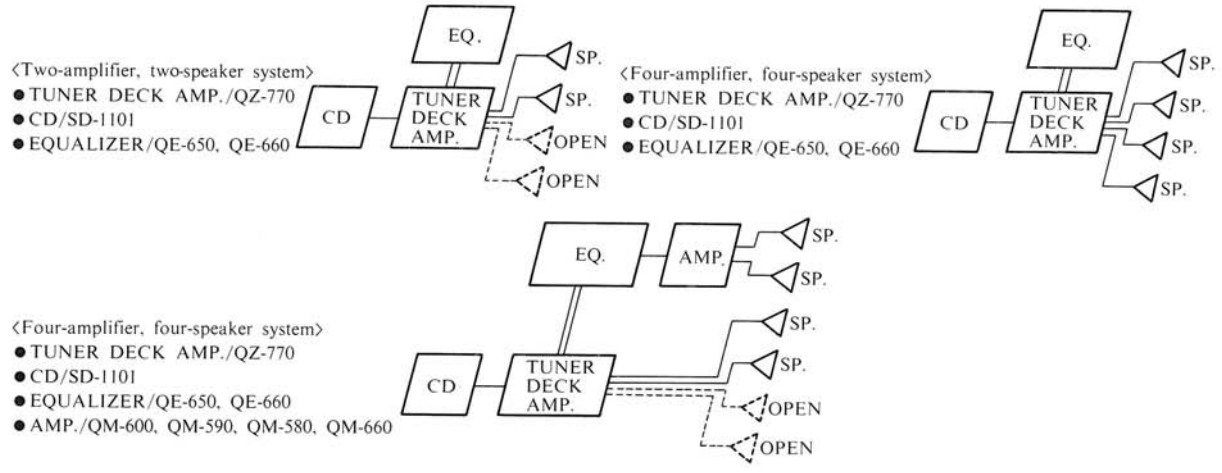


Figure 1. System configurations

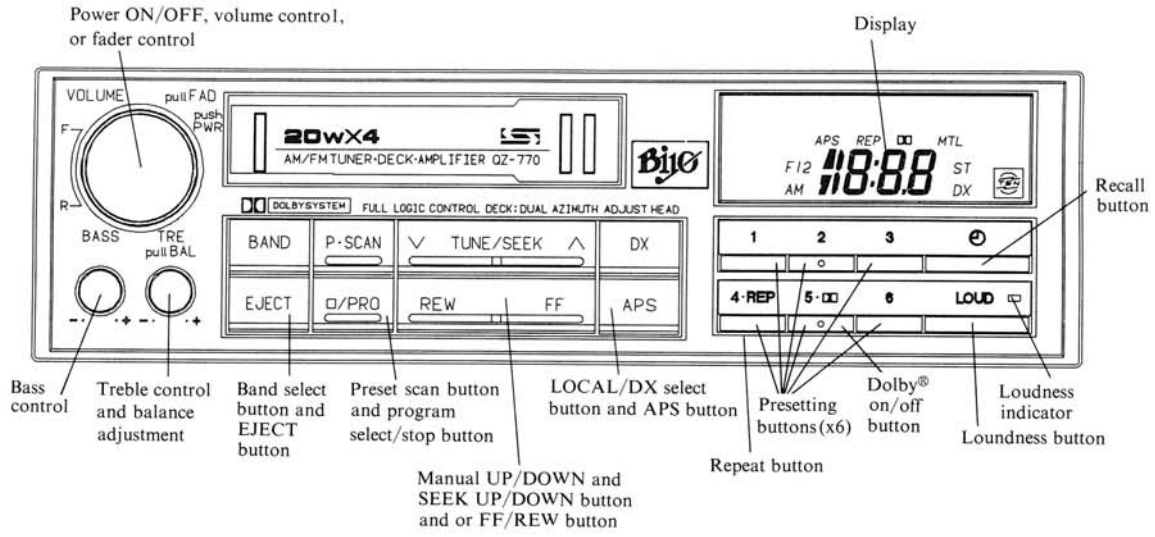


Figure 2. Appearance and major function of QZ-770

The system feature of the QZ-770 can meet the various requirements of users, from the basic system consisting of only the QZ-770 and a loudspeaker, to the full system with an equalizer, CD player, and high output power amplifier. Especially, the QZ-770 has the PRE-IN and PRE-OUT terminals so as to make use of four built-in power amplifiers with the maximum output of 20 W × 4. Since the conventional models have no PRE-IN terminals, external power amplifiers must be used when using a graphic equalizer. However, since the QZ-770 can return the graphic equalizer output to the PRE-IN terminal, High-power amplifiers with a total of 80 W can be used. Besides, the QZ-770 has an independent CD input terminal and a CD player can be connected to a graphic equalizer concurrently.

3.2 Design and operability

3.2.1 Design concept

When design was developed, fashionability was pursued besides good sound quality and performance so that the user gets a feeling of high quality from seeing and touching the QZ-770.

1) Feeling of high quality with least ostentation

The entire front section is designed composedly using intrepid black for the basic tone. Buttons use deep bright plating to express a feeling of high quality.

The display uses the front luminescent type VFD with two colors (red and blue) to express a feeling of high quality as well as to improve visibility.

In luminescent type fluorescent display tube the luminescent surface is nearer the front than in the conventional fluorescent display tube ($t_2 < t_1$) to provide a wider visual angle. (See Figure 3.)

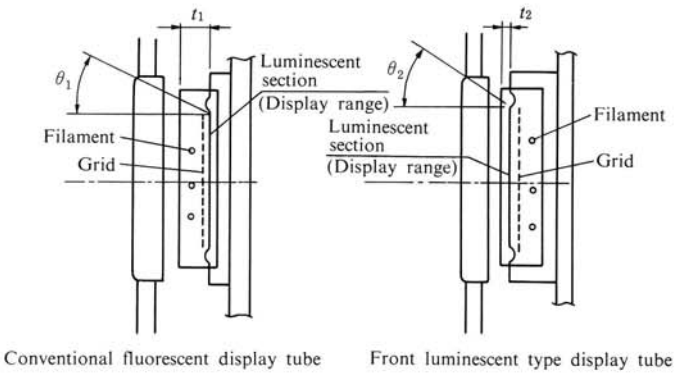
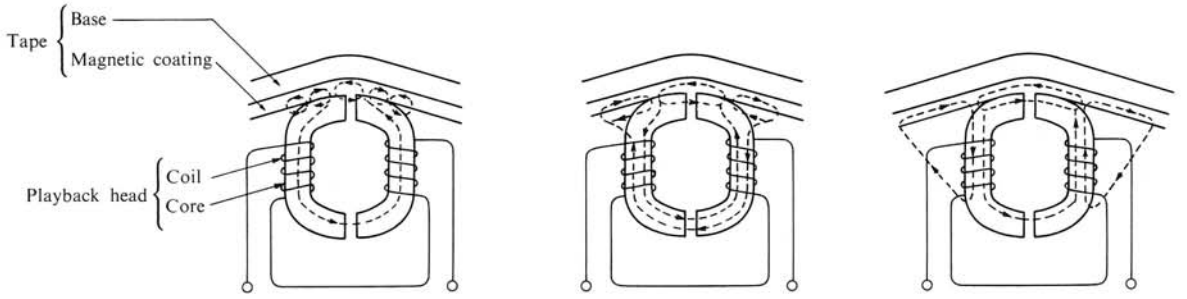


Figure 3. Comparison of VF visual angle



(1) Magnetic flux distribution when the wavelength is shorter than the head size

(2) When the wavelength comes near the head size

(3) When the wavelength is longer

Figure 4. Principle of contour effect

3.2.2 Improved operability and visibility

1) OPTI-MI button

The Optical Mode Indicator (OPTI-MI) that has been used in the conventional models developed and used in the operating buttons to improve operability and visibility at night. This indicator is used in the main operating buttons on the radio or cassette tape deck to switch the display in each mode. This indicator makes the function that is operated in each mode easier to understand and makes the dual-function buttons easier to use.

2) Buttons based on ergonomics*1

The main operating buttons of the QZ-770 were made larger and given a slanted shape, achieving a light operating touch and ease of use. In addition, blind-touch operability was improved by providing the boss on some buttons.

3) Pop-up knob

The BASS/TREMBLE knobs use the pop-up mechanism to improve operability by preventing fingers from touching other knobs. Since the projection of the knob is short during non-operation, safety is improved and the front panel is to be flat.

3.3 Hi-Fi reproduction technology

This section introduces the microprocessor-controlled tape deck and FM tuner circuits for stable reproduction of "Hi-Fi car stereo that is the desire of the hi-fi-phile."

3.3.1 Microprocessor-controlled tape deck

Like our component deck QD-650, the "DK-62" is also mounted on the QZ-770. This deck uses the dual azimuth mechanism to achieve stable playback of high frqeuency signals with the 1 μm/narrow gap head.

Low frequency characteristic was improved by using the "projection head" whose core shape was improved.

The frequency characteristics of the playback head is flat in the frequency range where the wavelength on recorded tape is sufficiently shorter than the length for which the head contacts the tape. However, if the wavelength approaches the length of the head-to-tape contact, waviness in the frequency characteristics may occur.

This waviness is generated by interference of the tape magnetic flux absorbed at other than the head gap. Because its effect depends on the core shape, this waviness is called "shape effect (contour effect)." Figure 4 shows how this shape effect occurs.

Figure 4 (1) shows that the wavelength is short and the contour effect does not occur. In this case, magnetic flux at other than the gap flows in the part where the core contacts the tape, which causes no effect.

When the frequency becomes low and the

*1 To change the machine so that humans can use it easily, by introducing human engineering.

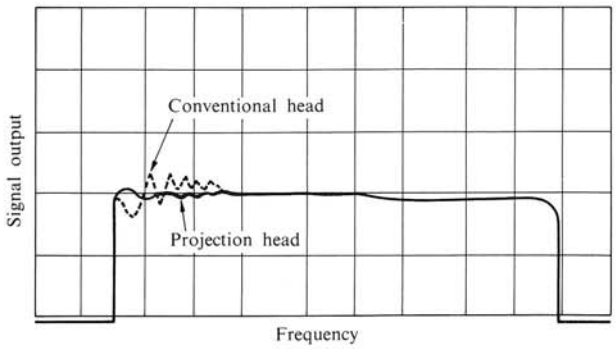


Figure 5. Frequency response of projection head

wavelength approaches the head size, magnetic flux distribution becomes as shown in Figure 4 (2). The magnetic flux at other than the gap flows in the direction opposed to the magnetic flux at the gap, decreasing playback magnetic flux.

At still lower frequencies, magnetic flux distribution becomes as shown in Figure 4 (3). The magnetic flux at other than the gap flows in the same direction as the magnetic flux at the gap, increasing playback signal output.

Although several peaks and valleys of waviness are also generated if the wavelength is shorter than the ones shown in Figures 4 (2) and 4 (3), the amount of waviness decreases, and finally no waviness occurs as shown in Figure 4 (1).

The projection head used in the QZ-770 has been improved so that the tape touches and separates from the core slowly, decreasing the effect of the magnetic flux absorbed at other than the gap.

This improvement decreases the shape effect, and improves low frequency characteristics more significantly than in the conventional models as shown in Figure 5.

3.3.2 FM tuner circuits

The important point for a car FM tuner is how clearly it can receive broadcasts a wide area with fluctuating radio signals. Consequently, in QZ-770 design, high sensitivity was emphasized.

Figure 6 shows the FM tuner circuit block diagram. Usually, the front end noise figure (NF) is improved and an IF buffer amplifier with differential input is used to achieve higher sensitivity; however in the QZ-770, it is a newly developed PLL detector that contributes most to higher sensitivity.

FM sensitivity is determined by the threshold level at which the signal-to-noise ratio (S/N) rapidly becomes worse when the peak of the noise component to be input to the detection stage exceeds the signal component. Therefore, the method of minimizing the noise component input to the detector stage, that is, to improve the front end NF described above is effective. It is, however, difficult to make NF improvement compatible with a good intermodulation characteristic. The PLL detection system used in the QZ-770 is an improved-threshold detection system that has been conventionally used for satellite communications.

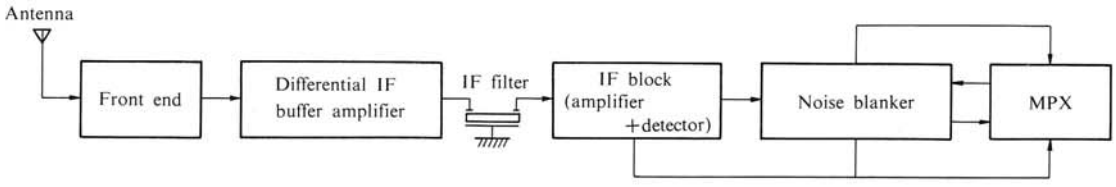


Figure 6. Configuration of FM tuner

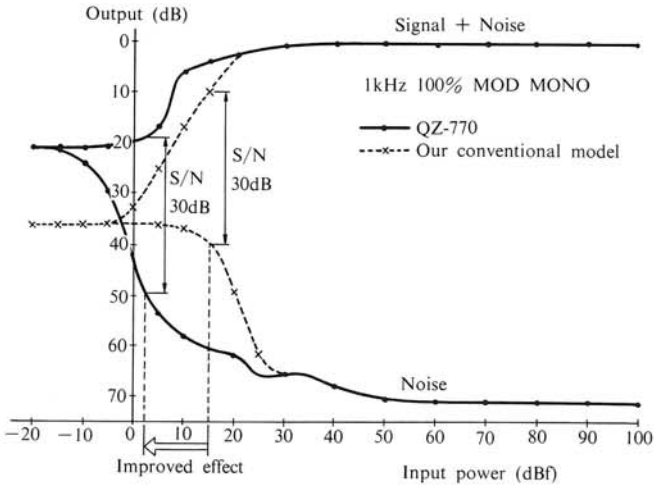


Figure 7. Limiter characteristics

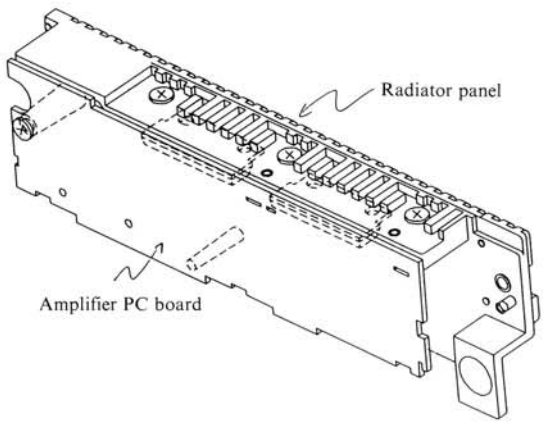


Figure 8. Construction of power amp. section

Figure 7 shows the limiter characteristics that are basic to FM receiving performance. Figure 7 shows that sensitivity has been significantly improved over the conventional model.

In addition to sensitivity, the advantages of the QZ-770 are that a low distortion factor can easily be achieved by using the PLL detector since PLL detection is frequency-follow-up type, and the QZ-770 is superior in rejecting adjacent channels since the VCO of the PLL detector operates at free-running frequency and does not perform detection even if a frequency outside the capture range is input.

3.4 Sound quality-oriented design

The QZ-770 regards sound quality as more important than the conventional models. High-power amplifiers are required even in a car so as not to degrade the sound quality of the CD source that has been in common use in recent years. The conventional power fader provides four power amplifiers with the maximum output power of only 14 W and a total of 54 W. If the conventional power ICs were used to make high-power 4-channel amplifiers, double DIN size would be required, and the QZ-770 could not be accommodated in one DIN size.

The QZ-770 has four high power amplifiers with the maximum output power of 20 W and a total of 80 W by using the newly developed power ICs in which two channels are configured on one chip. A powerful reproduced sound was obtained for sources such as CD, whose dynamic range is wide.

3.5 Heat radiation design

Sufficient heat radiation design is required to achieve 20 W x 4-channel high power amplifiers in the QZ-770. For this reason, the QZ-770 has a structure in which the heat radiation area is increased by mounting the amplifiers/radiator panels on the back of the set. Figure 8 shows the structure.

In the design, the following features were obtained.

i) The radiation area is 20% larger.
ii) The amplifier section can be made in a unit construction.
iii) Function changes can be followed without difficulty.

4. High-density package design

As previously described, this model incorporates a microprocessor-controlled tape deck and an electronic tuner and four amplifiers in one DIN size.

To achieve such a multifunction and small-size structure, higher-density design than conventional models is required.

The following describes major parts where high density and space saving design have been achieved in developing the QZ-770 model.

4.1 Integrating deck controller and tuner controller into one microprocessor

This model uses one microprocessor with 4K-byte ROM to control the tape deck and the electronic tuner.

This offered a 35 percent reduction in packaging space over the conventional models using two microprocessors with 2K-byte ROM for the deck controller and the tuner controller.

4.2 Packaging APS and EQ in one IC

The QZ-770 uses a newly developed IC with two functions of the deck head equalizer (EQ) and the auto program selector (APS).

The area occupied by ICs was reduced about 40% below the conventional system that has configured each function on a separate IC.

4.3 Dolby® hybrid IC

The QZ-770 series includes a model that incorporates Dolby® type B and a model that incorporates Dolby® type C.

Pin-compatible Dolby® type C HIC and Dolby® type B HIC were developed for the new model. Dolby® type B and type C can be switched by replacing HIC and inserting or bypassing a Dolby® C skewing coil.

High output power and multifunction in the limited space have been achieved by developing and putting in practical use these high-density packaging techniques. Performance has been improved over the conventional models by stabilized characteristics through module structure and circuit integration.

5. Conclusion

The purposes of the cassette player with an electronic tuner developed this time have been described and its design has been outlined. While users' needs for the car stereo system vary, and it has become increasingly difficult to meet their needs, the QZ-770 has produced results that meet the development concept, and has been fortunately popular since it was released. We will develop higher-density packaging techniques for further multifunctioning and digital technology for pursuing higher performance, and will make full use of know-how obtained in this development to develop subsequent products.

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