Bang & Olufsen

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The Beosystem 5000
A concept in human engineering

Bang & Olufsen

Contents

Full operating instructions for the Beosystem 5000 can be obtained by referring to the user manuals obtainable from your Bang & Olufsen Press representative.

The originals of the photographs in this book may be obtained by contacting your Bang & Olufsen Press representative.

CHAPTER 1
BEOSYSTEM 5000

The product philosophy

To the hi-fi enthusiast, designing ideal audio equipment involves relatively simple concepts. The finished system must offer the best possible reproduction of the source material – almost regardless of cost. What is more – it doesn't matter too much if it looks ugly, is large, consumes vast amounts of power, or has so many controls that it looks like the flight deck of Concorde.

This might be a suitable concept for small specialist manufacturers, but the number of hi-fi enthusiasts who have the money and the desire to buy such products is relatively small.

In contrast, the majority of consumers want technical quality, reliability and high fidelity from equipment which is reasonably priced and which fits into a domestic environment without looking like something father brought home from the factory.

The urge to buy a product just because it represents a new generation of technology has been strongly promoted by specialist magazines in the past. In the case of hi-fi, technical advances have been too often equated with improvements in reproduction. In some cases, this has been taken to the extreme of where the 'technical advance' is nothing more than an icon in the form of a technical – looking abbreviation.

Now the industry is paying a high price. Most consumers believe they have high fidelity equipment in their homes. By implication, they no longer need to change equipment just because a new technology or circuit improvement comes along.

This basic fact, coupled to the transfer of public interest towards the new generation of domestic electronic products – video and home computers, has led Bang & Olufsen to the admission that **hi-fi is dead**!

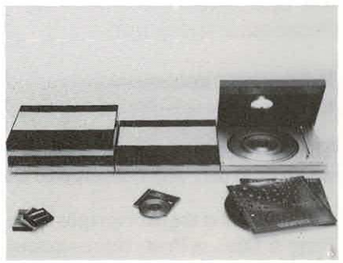
A fresh start, a new look

In contrast to the simplistic approach described above, Bang & Olufsen has always pursued two objectives when designing new products. Technical innovation has always been there. Indeed many products have either represented 'firsts' or have been given public accolades by meeting the most exacting standards of hi-fi reviewers.

In addition, and a rather more obvious demonstration of the company's skills, all Bang & Olufsen products have a distinctive styling which enhances the appearance of any home. They are not a brute example of 'full frontal technology'.

These two valuable assets have ensured the success of the company. They also represent an excellent foundation for a fresh approach and a new look for the next generation of audio products. One that does not seek to detract from the basis of technical excellence or simple beauty, but goes further to introduce the concept of applied 'human engineering' to meet modern needs and interests.

This is the Beosystem 5000.



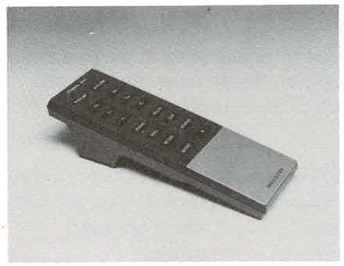
The system components

The Beosystem 5000 is the first of a series of products for the 1983/84 programme which reflects this philosophy. Engineered to high standards, it has a number of unique features designed to make operation totally simple and to reduce the number of controls to the bare minimum.

It comprises the Master Control Panel 5000, the Beomaster 5000 receiver; the Beogram 5000 radial tracking, belt drive turntable; the Beocord 5000 and an innovation for Bang & Olufsen, the Beogram CD50 Compact Disc player.

The Master Control Panel extends the system versatility by offering access to all essential controls of the system and adding a programmable timer as well.

The Beogram CD50 will reach the market later than the other components and is designed for total integration in the Beosystem 5000, or for use as a component in other systems. In the latter case, an optional extra infra-red control, Terminal CD50 is being made available.



Other components less obvious in an audio system extend the features of the LINK system. This is the Master Control LINK, a remote extension speaker system comprising a relay box, an infra-red transceiver, and the required special cabling.

Also available is a simple optional remote control unit, the Terminal 5000.

The full performance specifications for the Beosystem 5000 is given in Appendix 1 of this manual.

Beosystem 5000 control

Using the LINK system, originally developed for the Beosystem 8000, each component in the system can control the other in some way. Thus, simply loading a disc on the Beogram 5000 and pressing the start button will turn the receiver on, switch it to disc input, start the platter rotating and cue the arm to the lead-in grooves of the record.

Similarly, insertion of a cassette in the Beocord 5000 and pressing the play button will switch the receiver into the correct mode as well as starting the cassette deck.

The Master Control Panel extends this versatility still further by offering access to almost all of the system controls and adding a programmable timer as well.

Using LINK sensors and relay units around the house, the system can be controlled from any room. Additionally, the level control and muting of the extension speakers can be achieved using a Master Control Panel at that point. The same panel will switch functions, play a record (if there is one on the platter), or a cassette, if one is in the machine and can even programme the system to record from either disc or radio.

Above all, the secret of the Beosystem 5000 lies in the human engineering which results in a very simple control system. Almost all of the repetetive actions required to operate comparable hi-fi systems are, in the Beosystem 5000, undertaken by microprocessors located in each of the components.

System compatibility

Compatibility is an important word at Bang & Olufsen. For example, by taking advantage of the IEC standards for audio cassettes, the necessary switching for each type of tape (ie metal, Chrome and Ferric Oxide) is achieved automatically through the use of sensors which detect the coding holes on the rear edge of the cassette.

Compatibility of the recordings is ensured because each of the cassette recorder models has bias and equalisation set to standards which match the recommended tapes. The Beocord 5000 will always get the best out of a cassette that is to the IEC standard, regardless of the manufacturer.

But it does not stop there. Although the use of microprocessors has been extended in the Beosystem 5000, other Bang & Olufsen products can be connected and controlled, sometimes to a greater degree, by the Master Control Panel and the LINK system.

For example the Beogram 8002, the Beogram 6000, the Beocord 8004, the Beocord 6000 and Beocord 9000 can all be connected and controlled by the Beomaster 5000. Of course, the converse is true – Beosystem 5000 components can be controlled by other systems. The secret is in the standardisation of the LINK and remote control systems.

System protection

These days, we take electronic and electrial products for granted. They will guard themselves against our own worst stupidities.

We tend to overlook that, as the range of features and facilities grow from generation to generation, the possibilities for disaster also increase.

The phrase 'fully protected' must be familiar to anyone who, in the past few years, has considered buying an audio amplifier. These same products are 'protection limited' to permit the connection of two sets of loudspeakers at the most.

This is not the case with the Beomaster 5000 because the designers have come up with a method of using some of its microprocessor power in a unique way. The amplifier automatically limits the maximum output where too many speakers, or too low an impedance is connected to the output.

Another thoughtful feature is that the whole system shuts down to 'stand-by' after about 30 minutes of inactivity. This even extends to closing the drawer of the cassette recorder and Compact Disc player to avoid dust and accidental damage.

The Beogram 5000 will not play if no disc is on the platter and will always select a platter speed commensurate with the diameter of the disc. Of course it can't spot 12 inch 45rpm discs, but there is a manual speed override for such occasions.

The Beocord 5000 will not record on a cassette unless it has been programmed to permit it, by operation of the REC OPEN button and if the protective lugs at the rear of the cassette are intact.

Because of the built-in timer, the system can be used as an early morning alarm. However there is always the possibility of having left the system, the previous night, with too high a volume setting. The shock this might cause to the user can be avoided since the programming facilities sequence includes details of the preferred start up 'sound picture'.

Thus, the Beosystem 5000 not only protects itself from damage, but also offers features which protect the user!

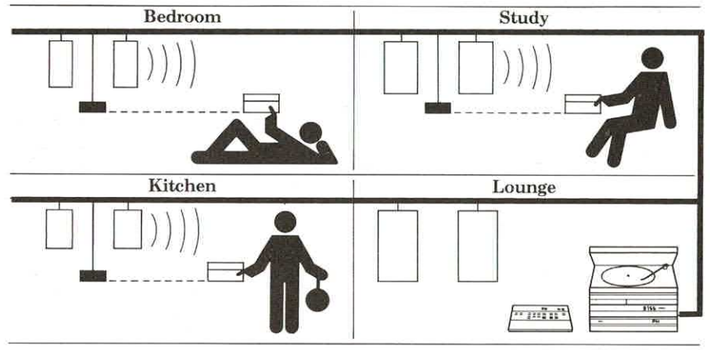
Extending the system

Extending any hi-fi system can be a problem. Especially if it is one that has some form of remote control.

What, for example, is the point of installing the system in the living room and a second pair of high quality loudspeakers in the study when the user has to return to the living room every time changes need to be made.

The Master Control Link, and the clever design of the Beomaster 5000 permits almost endless possibilities for extending the system. It ranges from adding extra components such as graphic equalisers, noise reduction units, and another tape or cassette recorder, through to the installation of additional control points or more loudspeakers around the house.

A typical possibility is shown in the accompanying diagram.



The main components of the system are located in the lounge – together with a Master Control Panel 5000. In the dining room, an additional pair of loudspeakers via Master Control Link are coupled to the main system.

Any of the components can be remotely selected and played. Local muting of any of the speakers is offered in the event of, for example, phone calls being received in that room.

In our example, a third speaker system is installed in the study using smaller units. Because their sensitivity may be different to that of the main system speakers, a manual adjustment of the maximum permissable volume is provided by the Master Control Link as a protection for smaller speakers.

Further power amplifiers can be connected to the loudspeaker outputs if LINK control is desired, or to the PREAMP OUT sockets where the main system controls the volume levels. These two possibilities could be used to meet the needs of active loudspeaker systems.

Thus, the Beosystem 5000 offers practical ways of extending the basic installation without sacrificing any of the system's resident versatility.

LINKS – Data LINK and Master Control LINK

There are two commonly held visions of the future home. The ideas are often seen in science fiction films or TV programmes, as well as often representing the theme of speeches by research engineers and technical commentators.

The first is the idea that a single, central domestic computer will control all the household functions and act as a 'butler', 'housemaid', 'bodyguard' and so-on. It will be a rather obvious system with a number of display screens, keyboards, sensors and probably voice communication as well. What is more, it may be imbued with some 'personality' to make its owners feel a little more comfortable.

The alternate view is less often described. Perhaps because it seems less exciting. It is that the home will be 'managed' by electronic systems which 'merge' into the household equipment and wiring.

Like the first idea, this too relies on computer techniques, but makes use of low cost distributed microprocessor 'brains', each dedicated to its own task, but capable of communicating to others in the total system.

Such a concept is probably more acceptable to most people – it is less likely to make a house look like something from a computer workshop. It also provides a more humanly engineered interface with the user.

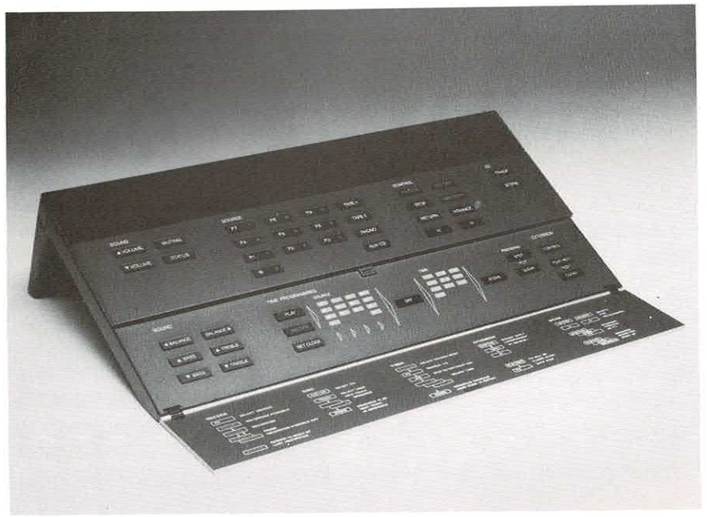
Bang & Olufsen engineers are convinced that the latter technique is right for future homes. It is the basis of the LINK system.

Each of the components in the Beosystem 5000 contain a microprocessor. These are used to accept commands from the control buttons and then to interpret the command into action.

Additionally the microprocessors act as communications transcievers that 'talks' to the Beomaster 5000 (or vice versa) via a single wire connection made with the audio signal lead.

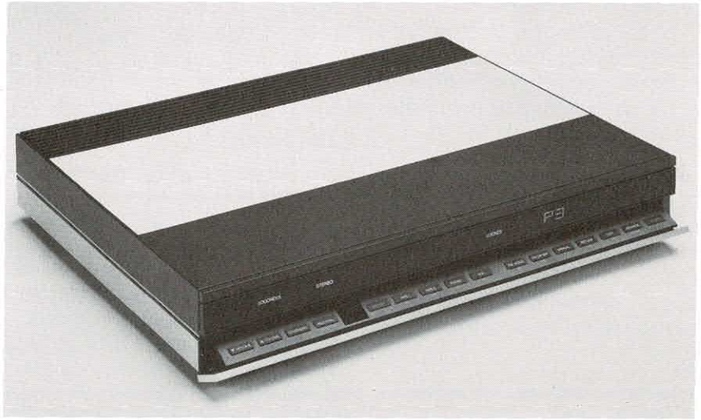
In the Beomaster 5000 microprocessor acts as the communications 'manager' as well as providing time programming, FM and AM signal processing, control of volume, bass, treble and balance and protection of the amplifier's output in the event of overload. The Beomaster's microprocessor is thus the 'brain' of the system, storing information on the status of itself and of connected system components.

The LINK system is so simple in its operation that the complexity of the controlling microprocessor circuitry is not obvious to the user. In effect, the control system has 'merged into the household wiring'.



The advantages of the LINK system become more obvious when considering the Master Control Panel 5000. It is a central control panel for the complete system giving access to any of the system components and any facility, without any of the complexity so often associated within component high fidelity audio systems. Here, the abstract concept of the LINK system has a physical manifestation and the human engineering becomes obvious.

CHAPTER 2
BEOMASTER 5000



Introduction

The Beomaster 5000 is the central component in the Beosystem 5000. It is the preamplifier, power amplifier and AM/FM tuner. But equally important, it is also the 'brain' that controls the rest of the components.

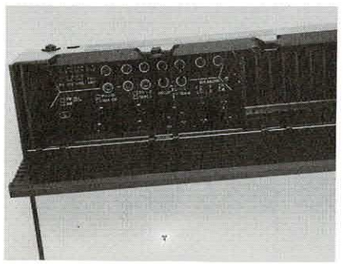
The system concept is firmly based on the principle of remote control, and so the Master Control Panel can be regarded as an integral part of the Beomaster 5000. The importance of this is seen when the range of controls available on the Master Control Panel is compared with those on the receiver. Certain of the preamplifier control functions are only accessable via remote control.

For convenience however, a full description of the Master Control Panel is reserved for Chapter 6.

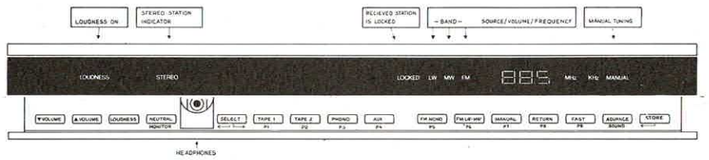
The Beomaster 5000 contains a large number of innovative features of which the most obvious is its apparent lack of controls. The front panel is simply engraved with only three legends. At the right hand end are the words PLAY and MUTE.

Pressure on this portion of the panel temporarily 'kills' or restores the sound output to the loudspeakers.

At the left of the front panel, the third legend, OPEN, indicates that pressure on this section releases the lower section of the panel to reveal the push button controls, mounted on a small 'desk' surface. Sixteen buttons are available, eleven of which can access alternate functions. In addition, a small port exposes the jack socket for headphones.



DISPLAYS:



SECONDARY:

The Beomaster 5000 is the only component in the system having rear mounted sockets. The accompanying diagram shows facilities for PHONO, TAPE 1, TAPE 2, 240 Ohm Aerial, 75 Ohm Aerial, Main and extension loudspeakers, CD/AUX, two Relay sockets and RCA type sockets for PREAMP OUT. The PHONO, TAPE and AUX sockets are provided with both DIN type connectors and RCA connectors, the latter being used with products from other manufacturers.

The tuner

The Beomaster 5000 tuner section contains a number of novel features, many of which were only made possible by the decision to make use of distributed microprocessor control for the complete system.

The most obvious of these is that all three bands, FM, MW and LW are automatically and optimally tuned using the ADVANCE and RETURN controls. Other features, not obvious at first, offer the possibility of storing de-tuned frequency selections. This is particularly useful where adjacent channel interference due to strong local transmissions is experienced. In some cases, the effects of multipath reception can also be minimised by storing a frequency slightly detuned from the correct value for the FM station.

Microprocessor tuning control

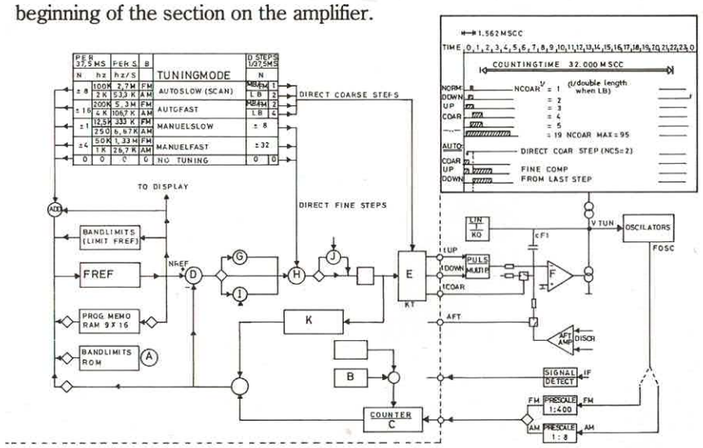
All tuning functions are under the control of a microprocessor which has access to electronic memories containing the preset station frequencies, the upper and lower frequencies of each of the wavebands and other internal signal parameters.

The digital resolution is 12.5 kHz for FM, and 250 Hz for AM. Further fine division is obtained in the AFT Lock modes.

The tuning system adopted is called FLL (Frequency Locked Loop). This uses the principle of taking two frequencies; the desired frequency and the actual frequency to which the tuner is currently set. It then compares them and then increments the tuning by steps which are proportional to the difference between the two numbers.

When compared to the more familiar PLL (Phase Locked Loop) tuning system, FLL uses signal frequency locking in the Automatic Fine Tuning mode. Thus, the FLL can continuously modify the tuning between the normal digitally generated raster steps. Another advantage is that, under the FLL system, manual tuning is possible without signal muting. But the main benefit of the system is that the same microprocessor used for frequency control, is also used to handle all other system control tasks.

The following more detailed technical description can be 'skipped' by the non-technical reader without losing continuity. The story can be picked up at the beginning of the section on the amplifier.



AM/FM FLL TUNINGSYSTEM

The block diagram is divided into two parts – on the left are the functions that are implimented in software in the microprocessor. On the right, are some of the basic hardware elements of the system.

During the description of circuit operation, two principal time cycles will be referred to. The first, of 1.562 milliseconds, was determined by the timing cycle of the first dedicated chip used by Bang & Olufsen for infra-red remote control. The time cycle has been preserved in the Beosystem 5000 for reasons of compatibility.

The second, longer time cycle is 37.5 ms, (or 24 of the faster time cycles) which is the basic timing of many of the events in the receiver microprocessor. A counter within the processor provides the timing sequences, and is updated by the microprocessor crystal controlled clock.

The unique design of the Beomaster 5000 tuner arose out of several requirements, and the experiences obtained from previous automatic tuning circuits.

The FLL system is probably easier to comprehend if one considers a start-up, unprogrammed condition.

Selection of the FM band, causes two memories to be consulted. (Marked A and B on diagram). Memory B provides information on the offset frequency of the main oscillator, necessary to produce the required IF (Intermediate Frequency), which in this example is 10.7 MHz. Memory A sets the starting and end points in the FM band from which the tuning will proceed. Memory A also contains information on the upper and lower band limits for MW and LW.

In the case of FM, the lower limit, and starting point for tuning is 87.5 MHz.

The information is fed directly into the FREF and to the 16-bit counter marked C. The FREF is a memory location (a RAM), which contains a code with a direct relationship to the desired frequency. The reference frequency is scaled and then decoded from binary to BCD before being transferred to the display, to obtain the display resolution of 100 kHz FM, and 1 kHz AM.

The output of FREF feeds adding point D where it is to be compared with a prescaled (1/400th or 1/8th) version of the tuner oscillator frequency.

In the first stage of selection of the FM band (or any other band) the tuner oscillator will be producing an incorrect frequency. Its output is fed via the FM or AM prescalers to the 16 bit counter which counts the frequency over a defined measurement time slot and passes the result on to adding point D. There, it is subtracted from the current FREF output. Any output from D therefore represents the difference between the frequency of the tuner oscillator and the frequency set within the FREF during the inital sequence.

In the event that the controls of the tuner have not yet been touched to alter the tuning, (the No-Tuning condition) the loop gain of the error detecting loop is set at 1/8th of the smallest nominal frequency step that can be made during manual tuning. This is to ensure that massive corrections are not applied to the tuner oscillator when the error may simply be due to drift.

The error pulses are fed directly to a PWM processor (marked E) which produces an output pulse, the width of which is proportional to the error.

Integrator F converts the pulse to a pump-up or pump down current proportional to the pulse width. This modifies the existing voltage set across the integrator capacitor C_{fl}, which is in turn applied to the varicaps controlling the frequency of the tuner local oscillator.

Successive cycles of this loop event reduce the error to zero.

A small amount of drift can occur in the oscillator frequency, due to leakage across the integrator capacitor. This produces errors at the summing point D in the microprocessor which are dealt with in a fashion similar to a start-up error.

Since the requirements of the pulse width generator and the integrator are different for fine tuning and coarse tuning, changes are made to the pulse train arriving at the PWM to suit the purpose. These will be described in more detail later.

The band limits memory is constantly compared with the output to prevent the FREF from being scaled outside the FM band during auto or manual scanning. Where there is a transition between the MW and LW bands, the FREF is modified from memory, to the adjacent band frequency limit.

The design of the tuner provides for several different modes of altering the tuned frequency. These are: AUTO FAST and AUTO SCAN, MANUAL SLOW and MANUAL FAST. (Preset tuning is dealt with separately).

As can be seen from the table in the accompanying diagram, operation of any of these buttons will produce a bit stream which is used to update the contents of the FREF. In the slowest mode of tuning, one bit per 37.5ms timing cycle will produce a shift in the FREF output equivalent to 12.5 kHz for FM, and 250 Hz in the AM mode.

Larger steps can be taken in the MANUAL FAST mode which produces 4 bits per 37.5ms time cycle and shifts of 50 kHz and 1 kHz respectively. Still larger jumps can be made in the AUTO mode where the maximum jump is 16 bits per cycle producing a 200 kHz shift in FM and a 4 kHz shift in AM. The bit stream can be ordered to act additively or subtractively on the contents of FREF.

The actual progression of the re-tuning of the oscillator does not, however, rely solely on updating the FREF. Changes are made in the error path to the PWM to set the loop gain and the tuning resolution. This is achieved by multiplication or division at G or I to obtain the optimum performance in all tuning modes.

Having established the lower limit frequency in the desired band, next assume a constant scan of the band using, for example, the manual tuning mode. At the moment of pressing the appropriate command button, the only signals changing the oscillator frequency are small errors appearing at the output of the summing point D. What is required is the direct injection of pulses into the error loop at the summing point marked H.

This will cause an appropriate pump-up pulse in the integrator and a change of approximately one step of resolution in the output of the oscillator. In turn, the output frequency is now compared with the new frequency stored in FREF which has also received an update. This technique ensures that comparison of the oscillator output is made with the last update of FREF, rather than the next update.

If the direct injection of pulses was not done, due to natural tolerances in the integrator, errors could accumulate during a constant scan.

When AUTO SCAN is selected, there is a small difference in the way that deliberate errors are introduced to cause scanning. To obtain the correct tuning speed, the direct step pulses are submitted in the coarse tuning mode, while the fine corrections from the former direct steps are submitted in the fine tuning mode.

Another problem which can arise in this kind of error detection loop arises as a result of the method of sampling the oscillator output. During scanning, the frequency of the oscillator may be sampled during a period of change. The output of the 16-bit counter will reflect this by a count that suggests the oscillator is operating well below its actual final frequency.

If this value is then applied to the summing point D, the error generated is larger than is required. Correction is therefore applied using a compensation (marked K) that calculates the counting error and adds a suitable number to the output of the 16-bit counter.

To achieve the range of resolution required by the integrator, whilst permitting the microprocessor time to perform other operations, the 37.5ms cycle of the tuning system is subdivided into 24 time slots of 1.562ms (See timing diagram) of which only zero and 22 are fully used by the tuning system.

Correction pulses of 96 different widths are possible, as slot zero is divided into four, giving a pulse of 1/4 width representing the finest resolution of tuning correction possible, or other combinations of 1/2 or 3/4 giving slightly larger correction. All other slots in the train have to remain integer values but can be added to the subdivided slot to give a high degree of precision.

Time slot zero is used slightly differently in AUTO FAST and AUTO SCAN. This is because time slot one is used to switch the input resistor to the integrator. The fine tuning pulse in slot zero is therefore placed at the leading edge of the time slot, instead of the trailing edge as in the previous example.

Stopping the tuning process in the AUTO SCAN mode is done when the proper signal status information from the receivers (FM and AM) is submitted to the system. If this stop pulse is still there in the next 37.5ms cycle, the system switches to fine error correction and locks to the station using the analogue fine tuning system.

This is an important feature in that the fine tuning, following scan tuning, is done automatically on any frequency.

Selected station frequencies can be programmed into a 9 x 16 RAM which can then be read directly into the FREF. In addition, other factors can be memorised including whether the selected station is to be switched to mono or stereo (this decision can be made by the user), or whether the stored frequency is detuned from the correct value. In such cases, the AFT is switched off as if in the MANUAL tuning mode.

This description of the tuning system is, of necessity, brief and incomplete. It should, however, serve to give the reader an overview of the unusual features of the circuit. Key elements include the ability to store detuned signals or deliberate selection of mono reproduction of stereo stations. Other programming systems do not permit these choices to be made..

The solutions chosen here represent a compromise between cost and flexibility. There is no compromise in the outstanding accuracy and stability of the tuning system.

The amplifier

The amplifier section of the Beomaster 5000 contains a number of innovations which represent considerable improvements in user control and system protection. Extensive use has been made of the receiver's microprocessor to achieve these objectives resulting in a totally novel method of protecting the amplifier output against overload conditions.

The LINK concept requires that all of the audio controls be accessed from the Master Control Panel. This requires the use of electronic means of adjusting volume, tone controls and balance. Preferred settings for each of these controls can also be stored in a programme memory and are automatically selected when the system is switched on manually or under timer programme control.

The range of the Volume control is 90 dB, divided into thirty, 3 dB steps, The setting selecting is indicated on the Beomaster display by numerals which range from zero to 6.0, with numeric steps of 0.2. In the case of the Master Control Panel, the display is in the form of a symbolic display rather than numbers.

Bass and treble have a total of 16 steps in 1.5 dB divisions, centred on a linear value and providing 8 steps up to +12 dB and 7 down to -10.5 dB. The balance control operates on the Left and Right channels in three 3 dB steps, two each side of the central position. Pressing the Right balance button once decreases the level from the Left channel by 3 dB. Pressed a second time, the Left channel decreases by a further 3 dB. Pressed one more time, and the Right channel is stepped **up** by 3 dB.

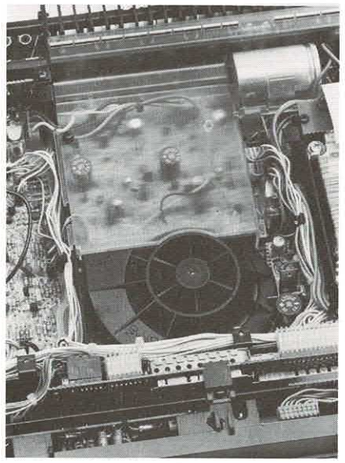
The tone and the balance controls are only to be found on the Master Control Panel, the displays being symbolic.

The Power amplifier

The Beomaster power amplifier is rated at 2 x 55 Watts (IHF) into an 8 Ohm load.
It contains a number of unusual features.

The small cabinet size, coupled to the high power output capacity has necessitated a different approach to the cooling of the output stage, when compared with earlier Bang & Olufsen receivers.

Instead of the massive and obvious external cooling fins, the Beomaster dissipates excessive heat via an internal heat sink, the sub-chassis and, under extreme conditions by automatically switching in a small internal turbo fan when the heat sink temperature rises above 50°C.



The turbo fan has a variable speed control, operating at low speed initially, and producing maximum air flow at approximately 95°C. Under normal conditions, the turbo rarely has to operate, but even when on, it is extremely quiet and cannot be easily heard.

The signal circuits in the power amplifier have been designed using principles established in earlier Bang & Olufsen products such as the Beomaster 8000, 6000 and 4000. The output stage is Class AB and has a high slew rate to minimise intermodulation distortion.

Transient Intermodulation Distortion (TID) is completely eliminated using the simple technique of filtering the input to the power amplifier stage to block all spurious signal inputs above the audible frequency range. This economic and elegant solution contrasts with some of the more 'brute force' and expensive techniques adopted in competing high fidelity power amplifiers.

A new feature employed in the Beomaster 5000 is a special output protection circuit that has been made possible by the presence of the receiver's powerful microprocessor.

Existing circuits, designed to protect amplifiers against anything from accidental short-circuit of the output terminals to overloading with too low a total loudspeaker impedance have the limitation that they either permanently disconnect the amplifier output stage until the fault is corrected, or they perform a series of temporary disconnection.

In either case, the effect upon the user is often salutary and alarming!

Overload can occur when either the temperature of the output stage becomes uncontrollably excessive, or the current drawn from the amplifier is higher than its rating.

Generally, the most likely fault conditions occur when too many extension speakers are connected to the output, or when the nominal impedance a loudspeaker system is below the rated range for the amplifier. In such circumstances, overload conditions may occur only at higher volume settings.

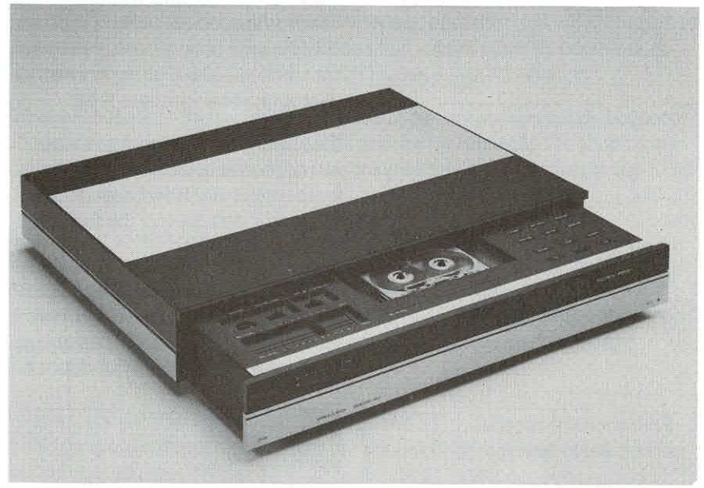
Using this fundamental fact and having microprocessor access to the volume control of the Beomaster 5000, Bang & Olufsen engineers designed a circuit that monitors the critical output circuit parameters and arranged that when any were exceeded, the upper limit setting for the volume control was reduced.

Thus, in a simple and unobtrusive fashion, the user is prevented from accidentally setting a volume level likely to produce overload in the output.

Once the upper volume level has been reduced, the volume cannot be adjusted to higher levels until the fault is cleared, or until the music level drops to lower levels.

The advantages of this form of protection are the elimination of distortion under overload, a smooth reduction in maximum power output under semi-critical fault conditions and a complete protection of the power amplifier under any fault condition.

CHAPTER 3
BEOCORD 5000



Introduction

The Beocord 5000 cassette recorder has an external design that matches that of the other main components. It was this that largely determined the adoption of a drawer method of access for cassette loading and operation of the main controls.

The Bang & Olufsen philosophy of dividing controls into primary and secondary levels, together with the adoption of the LINK remote control has reduced front panel controls to two – one to OPEN the drawer, and the second to PLAY a cassette.

The electronic design of the Beocord 5000 contains no radical innovations but clearly reflects the best of reliable, well proven techniques developed from other models in the Beocorder range. Features and performance specifications more than meet high fidelity requirements.

New electro-mechanical system

The tape transport mechanism and the majority of the transport controls are located on the upper surface of a drawer which is normally in the closed position. A power drive using a small, silent electric motor is used to open and close the drawer.

Placing the tape transport within a drawer is not in itself a new idea. Clearly the physical restraints of the cabinet design which demands the possibility for stacking the component 'bricks', coupled to the relatively slimline height, suggests few alternative solutions.

The technique, often employed in car stereo equipment of 'posting' the cassette into a mailbox style opening on the front panel was rejected on the grounds that access to the cassette in the event of jamming or any other failure of the mechanism would require an engineer's skills, and was therefore undesirable.

The basic philosophy of the LINK remote control system (described elsewhere), dictated the decision to adopt power operation of the drawer, purely manual operation being unsuitable in such circumstances. The final design uses a single motor driving through a gear, rack and pinion.

To open the drawer, the user presses the left end of the front panel surface, closing a microswitch connected to one of the inputs of the internal microprocessor. This, in turn applies power to the drawer motor for a period of exactly 5 seconds. Since the drawer takes a maximum of 4 seconds to fully extend or retract, and can be safely 'stalled', no additional controls are necessary to turn the motor off.

The significance of the 5 second 'power-on' sequence and the safe stalling of the motor is appreciated when considering a variety of events where the drawer may become jammed, either in opening or closing. For example, if there is an obstruction in front of the drawer, the motor stalls without danger, until the microprocessor switches it off.

This facility is more important when the drawer is closed, since a cassette could be misplaced, or a child could get a finger trapped. The amount of force applied by the motor is relatively small and therefore there is no chance of injury. When the motor switches off the finger can be withdrawn.

After switch-off, or indeed at anytime when the drawer motor is not active due to a fault condition such as power failure, the drawer can be manually opened or closed. This makes it possible to remove valuable cassettes, under any emergency condition. (Especially useful if the cassette belongs to your neighbour, and he wants to take it home!).

Finally, microprocessor control permits closure of the drawer as part of a total remote controlled shut-down sequence reverting the system to its 'stand-by' state.

The tape transport

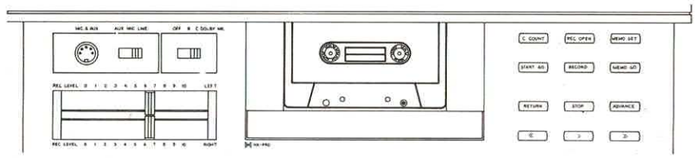
The tape transport is driven by a single, special custom-designed motor which runs continuously in a single direction. A combination of solenoid operated idler wheels provide the normal rewind, fast forward and play modes.

Since the transport is normally covered when the drawer is closed, cassette loading is extremely simple and free from error. Correct location of the cassette and head assembly is ensured by a complete 'table' located under the cassette, and guides on the head assembly which clip the upper surface of the cassette into place.

The Beocord 5000 uses two heads; a very efficient erase head, driven by an oscillator circuit derived from the acclaimed Beocord 9000, and a Canon MX record/replay head. They are made of materials having a high magnetic flux saturation level, making them suitable for use with metal tape types.

Frequency response is, to an extent, dictated by the head gap length which is 1.7 micrometres. Gap wear is kept to an absolute minimum since the spacer used is of titanium. Titanium also reduces magnetic gap losses thus improving the high frequency response.

The transport is fitted with the normal safety feature to sense the end of tape, or a tape jam and disengage the tape drive.



The control system

The Beocord 5000 is designed to be completely self-contained and thus can be integrated into a hi-fi system comprising other manufacturers' products. However, it is expected that normally it will form part of a Bang & Olufsen system using LINK remote control facilities. Thus, the 8048 microprocessor contained within the Beocord 5000 can be controlled by LINK, or by switches on the machine.

To the right of the tape transport, inside the drawer, a series of buttons provide all the transport functions. Unique to Bang & Olufsen, and found first on the Beocenter 7000, the REC OPEN button is a valuable 'fail-safe' feature preventing accidental recording of a tape.

This is necessary because the initiation of a recording session requires the operation of only one button, marked RECORD. Any cassette, whether protected by the 'safety lugs' being removed or not, when inserted in the transport is protected from accidental recording until the REC OPEN button is operated. Cancelling the REC OPEN function occurs when the cassette is removed or on pressing the REC OPEN button a second time.

It has been the experience of Bang & Olufsen that consumers rarely bother to protect their recordings from accidental erasure by removing the plastic lug at the rear of the cassette hence the reasoning behind the provision of the REC OPEN control.

Adjustment of recording levels, prior to the actual recording session is facilitated by a single operation of the RECORD button which partially engages the tape head assembly and connects the signal amplifiers to the metering system. At the same time a sign, RECORDING POSSIBLE, is illuminated on the display. A second operation of the RECORD button starts the tape transport and initiates recording.

Bias and equalisation for TYPE I, TYPE III and TYPE IV tapes is automatically selected using sensors which detect the presence (or absence) of holes in the rear of the cassette. *Note: Although a standard has not yet been approved by hardware manufacturers for the location of a sensing hole for TYPE IV tape, a sensor has been fitted in anticipation of acceptance of the current proposals being considered by the IEC. (International Electrotechnical Commission.)

In practice, almost all metal cassettes being sold now have the sensing hole provided, so the question of problems arising is somewhat academic.

The remaining buttons are exclusively concerned with operation of the transport. REWIND, PLAY and FAST FORWARD are marked with the normal symbols, ≪, >, ≫, and operate in the usual fashion.

Four other keys, RETURN, ADVANCE, START GO and MEMO GO provide special methods of locating specific points on the tape.

START GO rewinds the tape to the beginning, regardless of any setting on the tape counter, and then switches into PLAY; at the same time, the counter is automatically zeroed.

MEMO GO can be pressed to rewind from any location in the tape to a specific counter number which has been memorised by the operation of the button marked, MEMO SET. In the event of MEMO SET not being operated manually, it stores the zero counter position set when the cassette is first installed.

ADVANCE and RETURN are programme search buttons that permit the rapid locaton of any specific music item. Both rely on the replay head being partially inserted into the cassette during FAST FORWARD or REWIND, to sense the 'gaps' between musical items. Either button can be repeatedly pressed to access any selection up to 8 programme gaps away from the current position.

The RETURN button can also be used in the RECORD mode to stop the existing recording, rewind to the original start position and switch into RECORD PAUSE ready for a second operation of the RECORD button to start recording once again. To avoid the end of the previous recording being erased, a 2 second interval of blank tape is allowed between each programme initiated

with the RECORD button. If the RETURN button is operated, the recording circuits are switched off, the tape rewinds under the control of the counter memory and stops beyond the required point and then plays forward using the playback head to locate the 2 second gap, finally pausing at the end of the gap remote from the previous recording prior to switching on the erase oscillator.

Finally, the C.COUNT button will arbitrarily set the counter to zero, regardless of how much the tape has been used.

Signal processing

The Beocord 5000 incorporates switches to the left of the tape transport permitting selection of no noise reduction, Dolby B, or Dolby C. The Dolby HX Pro processing circuit, developed by Bang & Olufsen engineers and is permanently part of the signal processing circuitry.

Further signal controls offer input switching and two slide level controls to optimally adjust the recording level. The line input to the Beocord 5000 is via a permanently fitted cable, terminating in standard DIN connector. Since the AUX/MIC socket is located in the drawer alongside the input switch, there is no necessity to gain access to the rear of the machine at any time.

Adjustments to cope with the increased sensitivity required for a microphone is obtained using a low-noise microphone preamplifier, the output of which is switched to meet the starting point of the signal path for LINE or AUX sourced signals.

The audio signal is then passed through an FET impedance transformer directly to the input of the Dolby circuits. This is a monolithic integrated circuit having all the components contained in a single plastic block, giving the advantage of production economy and simple servicing.

The output of the Dolby circuit is then directed via buffer amplifiers to the head drive circuit.

Peak programme metering

A particularly interesting circuit feature incorporated into the Beocord 5000, is the peak programme metering. The signal level in each channel is sensed at the output of the buffer amplifiers. After rectification, the Left and Right metering signals are passed to switches which alternately select one or other output to apply to the display itself.

The multivibrator which provides the strobe switching is enabled by detecting a signal at the output of the rectifying cirsuits. Its output is not only used to switch the signal to the meter display, but also to switch the display synchronously to ensure that its input is directed to the correct 'line' of LEDs.

Determining how many LED bars to light, corresponding to the current input is achieved by pre-biassing the each light emitting diode from a ladder of resistors applying successively higher degrees of bias, dependant upon the increasing level of signal they are intended to represent. Each diode in turn will then light as the signal input to the diode array exceeds its bias.

By using the output from the strobe, the resistor ladder can be supplied with either a positive or negative reference which will bias either the left or right channel display and 'kill' the alternate one, in synchronism with the sampling of the left and right signal channels.

The strobe oscillator runs at about 100Hz, which is sufficiently fast to ensure the eye cannot detect flickering from the display, whilst still meeting the normal standards of attack and decay required of a PPM.

Dolby noise reduction

The Dolby B noise reduction system, invented by Dolby Laboratories Inc, has been the principal method of reducing the effects of tape noise in cassette recorders for a number of years. Although still an asset in any cassette recorder, its value was greater when first applied since a primary limiting factor in the performance of the audio cassette was the magnetic media.

Dolby B is a companding system, that is to say it alters the signal during recording by boosting low-level high frequencies above the tape noise and, on replay reverses the process to depress both high frequency noise and the signal itself into a correct spectral perspective.

Most pre recorded tapes available are recorded using the Dolby B noise reduction system.

The Beocord 5000 is fitted with the latest extension to the Dolby noise reduction system, the Dolby C. Similar in concept to Dolby B, it increases the noise reduction effect at high frequencies and, when used with the latest generation of low noise tapes produces results that effectively eliminate the noise problem from the audio cassette system.

HX Professional

The HX Professional system is a development of Bang & Olufsen and is licenced to other manufacturers through Dolby Laboratories as Dolby HX Pro.

It has been known for a long time that the adjustment of bias in tape recorders is a compromise between a value that produces the best distortion figures at low frequencies, and the best MOL (Maximum Output Level) at high frequencies. This is because the bias requirement reduces as the recorded frequency rises.

The problem is further complicated since the audio signal also contributes to the bias effect, particularly at high frequencies. The result is a reduction in the output at low frequencies in the presence of high level, high audio frequencies.

The earlier Dolby HX headroom expander works on the assumption that if the bias can be controlled in a dynamic fashion,more headroom can be offered at high frequencies. Usefully, the Dolby B noise reduction circuit contains an element that measures the high frequency energy present in the audio signal, and it was this that was used to reduce machine bias as the audio high frequency content increased.

Since any alteration to bias produces changes in the frequency response, the record preemphasis was arranged to be dynamically altered to compensate for the errors.

The result of this process was an increase in the amount of high frequency headroom available, and a consequent reduction in distortion. This system was aimed at obtaining the best possible headroom extension at high frequencies.

The HX Professional however, is designed with the object of obtaining ideal bias condition at all audio frequencies thus preventing dynamic changes in frequency response.

Since the objectives of HX Professional are fundamentally different, the control signal which is used to adjust the output from the bias oscillator is independant of the Dolby B circuit. Thus freed from the limitation of only being able to fit HX where Dolby B circuits were included, the HX Professional can be used in a greater variety of applications including professional products not incorporating Dolby B circuits.

HX Professional measures the signal at the record head to determine the actual bias effect of the combination of machine bias and the audio signal. The control signal is compared with a reference which is adjusted for the required static bias needed for the tape type in use, and a correction signal generated which is used to modify the output of the bias oscillator.

HX Professional needs no adjustment once fitted, and will operate correctly for all tape types without further correction. It can also be used in conjunction with any noise reduction system. It was first fitted to the Beocord 8002 and has subsequently been applied in the widely acclaimed Beocord 9000.

A detailed description of the HX Professional system is available on request, as a separate document.

CHAPTER 4
BEOGRAM 5000

Introduction

Making good turntables has, in recent years, been considered by many as an art rather than a science. This is nothing more than a suggestion that progress has been made by trial and error rather than the application of science and good engineering practice.

Bang & Olufsen have always been leaders in turntable, tone arm and cartridge design based on solid research and sound engineering principles. The result has often been products of radical appearance and advanced performance.

The Beogram 5000 is no exception to this rule. In fact, the cartridge, one of the new MMC series goes even further in that the design principles are confirmed by careful research into the controversy surrounding different types of cartridge perceived by listening tests.

The overall design result is therefore an automatic turntable featuring radial tracking, belt drive, microprocessor control, a special arm operating mechanism, and solenoid control permitting integration with the LINK system.

The front panel controls match those of the other Beosystem 5000 components. Pressure at the left end of the front panel trim causes the turntable lid to open. Pressure at the right end activates PLAY or CUE (temporary arm lift).

The tone arm is of extremely low mass and is designed to match the new and innovative MMC 4 cartridge. Less obvious features include a new pendulum suspended chassis of high mass, a platter offering better contact with the record and giving a more efficient means of static discharge, a high specification tacho-controlled DC drive motor and a special fast-operating cam system to control the movement of the tone arm cueing.

Suspension and drive

The mechanical design of a record player has to be considered as a whole since each element requires precise compromises to be made to optimise any one set of performance parameters. Nevertheless, the isolation of the platter and tone arm from external shock and vibration is considered to be of paramount importance and in this respect, the Beogram 5000 reflects a number of improvements in basic design principles to be found in other Beograms.

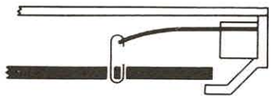
The platter, chassis and tonearm should move as one rigid assembly to avoid extraneous relative motion between the surface of the disc and the body of the cartridge. Such motion would produce an unwanted signal from the cartridge.

Since the tone arm, of necessity, has to have two degrees of motional freedom and has its own inertia, undesirable relative motion can occur as a result of vibration from the motor, the platter bearing, vibrations in the tone arm or chassis, or external shock or vibration.

The solution to this complex set of problems has produced a variety of turntable designs, each of which is a compromise which plays off one performance parameter against another. The Beogram 5000 uses new ideas and materials which combine to produce a turntable of high performance and simplicity of operation.

The starting point is to design a suspended chassis that is isolated from external shock and vibration but which has a motional resonance well below that of the tone arm and the lowest frequency found on a record.

The Beogram 5000 chassis is a heavy (2.5 kg) steel plate suspended on pendulums from three flat leaf springs fixed to the chassis. A low resonant frequency of 5 Hz has been obtained by this method. This is difficult to obtain using conventional coil springs since they need to be long – thus dictating a deep case. Additionally, it is extremely difficult to match the characteristics of such springs, as well as to damp them to prevent excessive motion at the system resonant frequency.



The dimensions of a leaf spring are relatively easy to control and, even in a low-profile cabinet, occupy little room since the all-important length requirement is obtained horizontally. The main depth requirement is needed to give sufficient length to the pendulums which damp the suspension as well as converting lateral shock into vertical motion.

A low centre of gravity is obtained by placing the steel plate chassis so far down in the casing that it replaces the conventional base of the turntable.

The platter, which is also of new design, is aluminium and coated with six concentric rings of Nextel – a resin containing small rubber balls. Because the Nextel rings are thin, the disc sits extremely close to the metal surfaces of the platter producing a very effective grounding for static charges.

Although the platter appears to ring like a bell when struck (not a desirable feature for any turntable!), the design is such that this completely disappears when the record is placed on the platter. This eliminates the need to apply weighty damping compounds to the underside of the platter and keeps the mass and thus the inertia low. All this facilitates fast start-up times.

Tone arm

Nowhere is the complexity of engineering compromise more evident than in the tonearm of a record player. Since it is an extension of the chassis it is required to be as rigid as possible, but since it has to be moved by the stylus tracking in the record groove it should also display a low moment of inertia.

The material used for the tone arm of the Beogram 5000 is stainless steel. Since this is a high density material, one might suspect that the mass of the tone arm would be high. However, such is its rigidity that the tube diameter can be reduced to extremely small proportions without any sacrifice of other important performance parameters.

Typically, if the arm were to be made of aluminium or brass in the same tube dimensions, a measurable flexing resonance would appear at approximately 300 Hz.

The mass of the arm has been kept so low that together with its MMC cartridge, the effective mass at the stylus tip is only 6.8 grammes and the motional resonance of the arm with its de-coupled counterweight is 14 Hz vertical and 12 Hz horizontally.

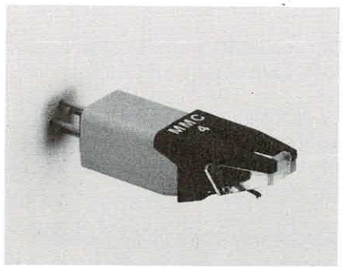
The arm is suspended on a knife bearing on a hard rubber seat and pivoted on a single point bearing. Skating compensation is fixed for the cartridge fitted and comprises a thin coiled spring located beneath the arm's vertical bearing.

Finally, the arm has been designed to further minimize the tracking error always found in radial arm designs. This is determined by three factors; the effective length of the tone arm, the offset angle of the cartridge and the overhang – the distance along a straight line from the pivot, between the record centre and the stylus tip.

Most radial arm designs optimise these three factors to minimize the tracking error at the end of the record where recorded wavelengths are smaller and thus produce bigger distortions.

However, Bang & Olufsen have adopted a new design philosophy in which the arm geometry has been adjusted to produce the lowest total distortion across the entire record diameter. This achieved by taking a weighted value for tracking error which reflects the values of distortion. The weighting is simply obtained by raising the tracking error to the second power before using it in design calculations.

The result is a more evenly distributed, lower level of distortion than is found with more conventional designs.



Cartridge

The MMC 4 cartridge fitted to the Beogram 5000 is one of a series where the design was influenced by two factors; the need for a new low mass design to complement the new Bang & Olufsen radial tone arm designs, and the results of new research.

The starting point of the research was a series of listening tests designed to establish whether there were any definite listener preferences for either moving coil, moving iron or moving magnet cartridges.

If such a preference could be established, the next stage was to determine the design features responsible and to incorporate these, in an improved form, in a new series of Bang & Olufsen cartridges.

Listening tests were conducted using a professional panel comprising experienced reviewers as well as an in-house team of auditors. Two important conclusions were drawn from the tests. First, there is no particular preference for any one type of cartridges providing all are of equal engineering and design standards. Second, preferences that were established correlated well with the phase and amplitude responses of the cartridges.

This laid the foundation for the new cartridge design. A flat frequency response that extended well beyond the audio band, low mass, well controlled mechanical resonances and an output commensurate with the sensitivity of modern pre-amplifier PHONO inputs.

The MMC 4 is a moving iron cartridge which utilises the Bang & Olufsen patented iron cross system, a tapered tubular aluminium cantilever and an improved cantilever pivot and magnetic circuit.

Being a direct plug-in design, the body mass is extremely low (only 1.6 grammes) producing an optimal mechanical match to the tone arm.

Cartridge resonance

At high frequencies, the main feature preventing a flat amplitude response are the natural resonances of the cantilever system which produce a peak part of which often appears within the audio band. Usually this is damped using rubber elastomers at the cantilever pivot, but this has problems since it is difficult to ensure repeatability in production, and stability over a range of temperatures.

In practice, there are two mechanical systems producing high frequency resonance. The first is the compliance of the record vinyl reacting with the mass of the stylus cantilever assembly; the second is the compliance of the cantilever reacting with the mass of the micro-cross and the rubber pivot.

In the MMC series of cartridge, both these systems have been designed to resonate at the same frequency. The result is the almost total elimination of undesirable motion at the resonant frequency, and the creation of two smaller and much more diffuse resonant points either side of the cancelled resonant frequency.

This reduces the need for damping and results in a smooth amplitude response that is flat up to 20 kHz and has a phase response that displays no significant phase rotation up to the same frequency.

The stability of the elastomer bearing has been improved in the MMC series since a new bearing assembly has been designed, in which a nylon restraining wire contributes around 10 percent of the system compliance and is unaffected by temperature changes.

The pivot point of the micro-cross also is now better defined because a metal bush, fixed to the inner housing of the cartridge extends through the elastomer to the rear of the micro-cross. This ensures an accurate symmetrical movement of the micro-cross, reducing distortion and improving crosstalk.

The compliance of the cartridge is fixed at 25 micrometres/mN which produces a tone arm resonance at between 10 and 15 Hz – well above the chassis resonance, and the warp frequencies found in normal records, but below the music frequencies.

Magneto-electric system

Taking advantage of new technical advances in magnets, Bang & Olufsen have produced a new design of magnetic circuit that reduces losses in coil and magnetic circuit producing lower levels of distortion and a lower cartridge weight without any reduction in the signal output to the amplifier.

This has been achieved by using a new magnetic material having a higher magnetic strength for its physical dimension and mass, and placing it directly at one side of the air gap, instead of in the former remote position at the end of the coil pole pieces.

This arrangement is illustrated in the accompanying diagram which shows the Samarium Cobalt magnet designed as a rectangle pierced by a hole to admit the cantilever. Compared with the MMC20 cartridge, the new magnet occupies only 2.2 cubic mm as opposed to the MMC 20's 48 cubic mm.

The design of the electromagnetic system is in no way a compromise for any shortcomings in the mechanical system – the two are independantly optimised. The result is a cartridge of unusually small size, having outstandig linearity, a high immunity to external hum fields and which is relatively noncritical with respect to electrical loading.

Automatic features

The mechanism which positions, raises and lowers the arm of the Beogram 5000 is elegantly simple and novel.

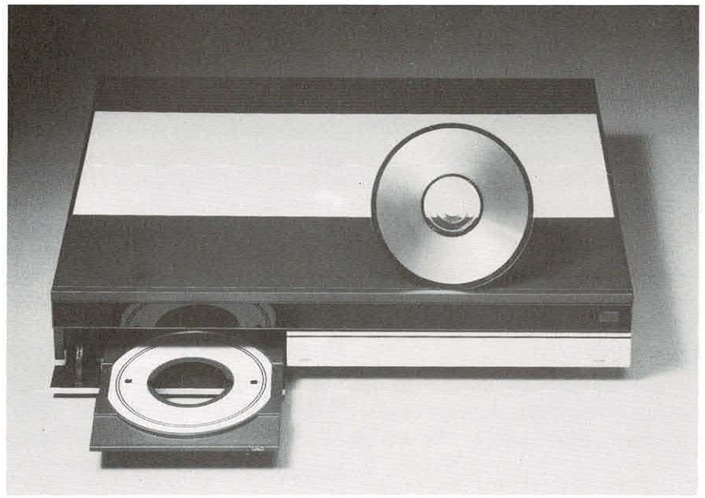
Two special plastic gear wheels are designed such that a section can be disengaged from the drive gear on the platter spindle. If the solenoid is actuated, the section slides into place to complete the circumference of the gears and engage with the spindle drive. When the gear rotates, the arm is raised or lowered, moved to the edge of the disc, or returned to its position of rest.

The simple solenoid actuation coupled to a microprocessor makes it possible to automate the deck functions and control them via the LINK.

Upgrading the system

The new MMC series of cartridges feature a universal plug-in mount and range from the standard MMC4 fitted to the Beogram 5000 to the superb MMC1. All may be used in the Beogram 5000 tone arm, the benefit obtained being commensurate with the qualities of each cartridge. The only change necessary is a minor adjustment of vertical tracking force.

CHAPTER 5
BEOGRAM CD 50



The Beosystem 5000 is the first from Bang & Olufsen offering a Compact Disc player as a signal source. The Beogram CD 50, due for release after the rest of the system, has the same external physical appearance as all the other system components and can be operated from the Master Control Panel.

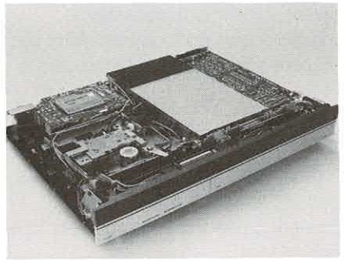
As it is the first CD player to originate from Bang & Olufsen, the possibility that it may become a popular component to be integrated in systems from other manufacturers has not been overlooked.

The Beogram CD 50 is fitted with its own infra-red receiver which can accept commands from an optional Terminal CD 50. Thus, whether integrated in the Beosystem 5000, or with other hi-fi equipment, the extensive remote control function remains available to the user.

The Compact Disc system

The CD system, first invented by Philips and developed by Sony and Philips jointly, had its European commercial launch in the Spring of 1983. It essentially represents a new format for records where the signal is in the form of a digital code which is 'read' by an optical system contained within the CD player.

The discs which are 12 cm in diameter carry the recording on one side, the other being reserved for the label. Up to one hour of music or speech can be recorded on the disc. A large number of record labels have taken licenses to produce discs, including the Polygram labels, EMI, CBS (and their Japanese joint venture CBS/Sony), RCA, Erato and Nimbus among many others. Approximately 500 titles will be available by the end of 1983, the numbers increasing rapidly after that date.



The recorded surface of the disc is optically prepared by being 'plated' with a thin film of highly reflective aluminium which is itself protected by a thin layer of transparent plastic. This highly durable surface is resistant to damage and easily cleaned. Nevertheless, should minor scratches or dirt cause surface defects, the method of optically reading the record and the special digital coding format ensures that these faults will rarely, if ever, be heard.

It is important to realise however, that although the **disc** may be digitally recorded, the **studio master** from which the record is made, may be analogue or digital! Normally, discs which have come from a digital master are marked with the words, 'Digitally Mastered'. Nevertheless, the real advantage of Compact Disc is that no matter what the source material, the disc player will replay it as if the user is listening to master source material.

Compact Disc players are also being manufactured by a large number of licensees although, as is the case with many new technologies, supplies will be limited in the early days. This equally true of the Beogram CD 50 which is likely to become a 'collector's item' because of its stylish appearance and superior range of facilities.

The disc recording format

The recorded signal on the disc is arranged as a single spiral track running from the centre of the disc to the outer edge. The original analogue studio sound is first encoded using Pulse Code Modulation.

Several stages of additional processing then follow which are designed first to 'protect' the signal from errors due to missing bits of information, but also to provide special information and control data to the player.

The following processes include re-formatting the PCM code using Eight-to-Fourteen bit Modulation (EFM) and multiplexing the left and right channels. Protection is then built into the signal by adding check bits enabling the player to confirm if there are errors occuring, and finally adding a sophisticated error compensating code and interleaving the data blocks in a special sequence involving repetition, to permit replacement of data under error conditions.

The additional data recorded provides a 'directory' at the beginning of the disc of the number of tracks, and at a later date may include simple texts giving titles or other information on the content of the disc. Included in the record data stream are codes which permit display of the track number, the elapsed time, and the time remaining to the end of the track.

The error correction code is heirarchical, which means that the player's error correction circuits can be designed to make partial or full use of the error correction techniques. Thus, it will be possible to hear differences between players manufactured to different price specifications. Similarly, use of the display data is optional – it can be partially or wholly used, dependant upon the requirements of the designer.

Compact Disc quantises the original analogue signal into a 16-bit code which provides a theoretical maximum of over 98 dB of dynamic range. However, this can be degraded either because the digital to analogue converter (D/A converter) produces errors in interpreting the least significant bits, or because circuits subsequent to the D/A converter introduce noise or distortion.

The recorded bandwidth of the Compact Disc is, to a large extent determined by the frequency used to sample the original analogue signal. This is 44.1kHz which sets the upper frequency limit to 20kHz. On decoding, the reproduced audio appears as the lower sideband of a 22kHz 'carrier' and two sidebands of multiples of that central frequency.

Clearly any signal above 20kHz is unwanted, so a special steep cut low pass filter has to be introduced to prevent spurious signal appearing at the player's audio output. Different player manufacturers have adopted various techniques to solving this problem, but an important point to bear in mind is that any evidence of the 44.1kHz appearing at the audio output is not a function of the filter performance, but merely a question of poor signal earthing techniques in the internal circuits of the player.

Disc fault compensation

Assuming the player has full error compensation, the digital circuits are capable of coping with massive losses of data amounting up to 2.8 mm of a track. However, other problems can arise if the cause of the data error is a disc surface defect affecting a number of adjacent tracks.

These problems concern the 'steering' of the optical reading head of the player. In all players, the head comprises a laser, a focussing lens system and a photosensitive diode that detects the amount og light reflected from the surface of the disc. The steering of this unit across the disc relies entirely upon the ability of the photo-diode to detect the relative position of the focussed laser beam in respect of the disc track.

If this information is missing for a short time, the time constants of the servo control loop which includes the steering and focussing motors are adjusted so that the track is correctly picked up at the other side of the defect. Where the defect is above a critical size, (smaller than 2.8 mm!) a number of things may happen, dependant upon the design of the steering circuit. The player may jump to the adjacent track (if it too has not been obliterated), or a 'locked groove' effect may occur.

Worse, since the speed of the disc changes as the position of the reading head moves towards the outer edge of the disc and the drive motor gets information on its correct speed from the record, the motor speed control can run 'amok' when massive disc faults occur.

It is possible to avoid these problems using a carefully designed strategy for the electromechanical circuits, but the examples given show some of the considerations necessary to ensuring a reliability in the electromechanical system that equals that of the data correction circuits.

The Beogram CD 50

Compact discs are loaded into the Beogram CD by a motorised drawer at the left end of the player. Touching the left end of the aluminium front trim causes it to open. The disc is placed in the circular depression in the drawer, reflective side uppermost and the drawer closed either by touching its front surface, or by switching the player to the PLAY mode.

In the event that a disc is incorrectly located, or is upside down, the drawer automatically re-opens.

Player controls are revealed in a similar manner, by touching the left end of the remaining section of front aluminium trim. The right hand end of the trim, when pressed will cause the player to switch to PLAY.

Thirteen control buttons provide the functions described below:

PLAY: In the event that the player has not been programmed to play specific tracks, or a specific sequence of tracks, this button starts the machine playing the disc from track 1 to the end of the disc.

Within the first few revolutions of the drive motor, a display at the left end of the front panel illuminates to show the number of tracks on the disc, up to 15 tracks. If there are more, an arrow is also added to the end of the row of numbers. The display also shows, with a small red flashing underline, the track number being currently played, and with a fixed red underline, the number of the next track to be played.

SCAN: This is a feature unique to the Beogram CD 50. The first 12 seconds of each track is played in succession. If the full 12 seconds is played without rejection by pressing the CLEAR button, the track is selected for playing in a later sequence. More rapid acceptance of the track into the memory is obtained by pressing the STORE button while the first 12 seconds of music is playing. The machine then moves to the next track.

During SCAN, the track number flashes above a flashing red underline. If rejected, the track number disappears. If programmed, the first selection is underlined by a fixed red light, and the number remains illuminated. Also during scan the legend SCAN ORDER appears at the right end of the display panel.

When all tracks have been SCANned, the machine returns to the first selection and commences playing the complete programme of music chosen.

The SCAN feature is accessible on the Master Control Panel by pressing AUX-CD, TRACK, and ZERO (STANDBYE).

STOP: Pauses the player for up to thirty minutes after which time it reverts to STANDBYE.

ADVANCE: Advances the player from the current track to the next one to be played. Can be pressed more than once to advance an approriate number of tracks.

RETURN: Returns the player to the beginning of the current track. Can be pressed more than once to return over an appropriate number of tracks.

≫: Pressed once, causes the reading head to be fine cued forwards. The process is stopped by pressing PLAY (permitting cueing in mid-track), or STOP. If the facility is left switched on to the end of the record, the player resets the pick-up to the beginning of track 1 and switches to STOP.

≪: Action is as above but in the reverse direction.

DISPLAY: Different displays showing the position of the pick-up can be obtained by pressing this button three times. These are the track number indicated in the form :01, :02 etc; the total elapsed time from the beginning of the disc indicated in the form 00:01, 00:02 etc; the elapsed time from the beginning of the track indicated in the form 0:01, 0:02 etc.

It should be noted that the total elapsed time includes the disc space taken up by the directory at the beginning of the disc, whereas the track elapsed time does not. Therefore, on track 1, there will often be a small difference between these two displays.

CALIBrate: Pressing this button once connects an internal reference oscillator to the audio output of the Beogram CD 50. This can be used to establish optimum recording levels on the Beocord 5000, or for checking system loudspeaker balance. Pressed once again, the tone is disconnected and the disc output restored. The CALIBrate button can be pressed at any time without affecting any of the other player functions.

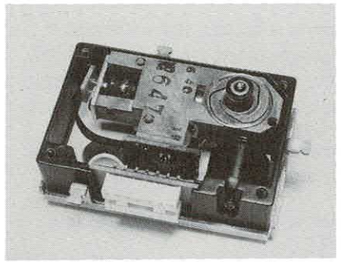
REPEAT: When pressed up to four times, the player will repeat replay the tracks selected the number of times the button has been pressed, or until the STOP button is pressed which then cancels the request.

Programming track selections can be achieved using one of two methods. After loading the disc, the STEP and STORE buttons can be used together to select tracks to be played. Conversely, where only a few tracks are to be rejected, the STEP and CLEAR buttons can be used to eliminate unwanted tracks from the programme.

Tracks retained in memory are indicated by the numeral remaining illuminated, the numerals of all CLEARed tracks are blanked out.

Programming can take place at any time, but each step in the sequence must be completed within 15 seconds.

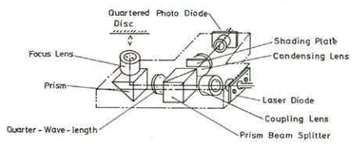
CLEAR: Can be also used to clear programmed track selections in conjunction with the STEP button, or clear the whole memory, leaving the player to simply play all tracks in a normal sequence.



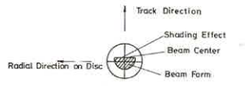
Technical description

The optical assembly used in the Beogram CD 50 is a complete and small unit made by Maruman. It offers several advantages over other types, not the least of which is that it is slim and so can easily be fitted into the dimensions of the Beosystem 5000 cabinet.

Light from the laser passes through a condenser lens, the prism and a quarter wave polarizing plate and finally the voice coil driven focussing lens. It form a single fine point of light directly at the reflecting surface of the disc.



Light returned from the disc passes back via the focussing lens and the quarter wave plate to be selectively reflected through 90° by a surface that detects its polarisation. The circular beam is partially cut off from the opto-diode to provide a means of detecting out-of focus conditions.



The diode is divided into four, and the digital signal derived from summing the signals from each quadrant. In the event that the beam is incorrectly focussed, the amplitude obtained from the unshaded quadrants rises or falls in respect to that from the shaded quadrant. This drives a servo loop controlling the voice coil surrounding the focussing lens.

Similarly, tracking errors are detected by relative changes in amplitude from the summed outputs of the left and right halves of the diode. The error signals feed a servo loop which then drives a voice coil to push or pull the optical assembly sideways.

This motions copes with small errors, usually caused by eccentricities in the disc. It does not cope with the error which arises from the need follow the spiral track. An extension to the servo loop, connected in parallel detects lower frequency deviations and provides an error correcting drive to the rack and pinion carriage drive, carrying the optical assembly.

EFM demodulation, stripping out of synch pulses and data is done by a Sony manufactured set of integrated circuits.

The digital to analogue conversion is a critical process, since it determines the degree of accuracy in approaching the theoretical limit of dynamic range and distortion dictated by the quantising. Bang & Olufsen have opted for an expensive solution, by using a full 16-bit D/A converter made by Burr-Brown for instrumentation purposes.

The accompanying chart shows the theoretical performance for D/A converters ranging from 12-bit to 16-bit, together with the actual curve (the denser line) for the Beogram CD 50. Departures from the theoretically perfect line can be due to the inability of the D/A converter to resolve the two least significant bits or,

more mundanely, due to noise or distortion arising in the subsequent filters buffers and audio output amplifiers.

The Burr-Brown D/A converter meets very high standards of performance, and this is matched by the following circuits.

Anti-aliasing filtering is provided by a very accurate 9 pole hybrid active filter that, in pre-production testing has been shown to have a remarkable stability and repeatability. The phase characteristics of the filter are linear to at least 15 kHz before the normal phase rotation, associated with complex steep cut filters, begins to occur.

In error conditions, the Beogram CD 50 produces a fine performance. The problems of disc faults promoting tracking or focussing errors is minimised by the single-beam optical system. This is because in the three-beam system, track location is determined by two extra small spots of light either side of the track, one ahead and one trailing the main beam. If a fault occurs it will be sensed by the leading beam first, then the trailing beam. This gives two successive massive error signals in oppsite directions which could lead to track jumping.

The single beam technique of track sensing avoids this since any defect will usually affect the total area of the light beam, preventing sideways errors in the servo loop.

In fact, the time constants of the all servos for disc drive, focussing and track following are optimized for the case (hopefully a normal one!) where the machine is resting on a stable surface free from major vibration and the only errors to correct come from the disc.

Control circuitry

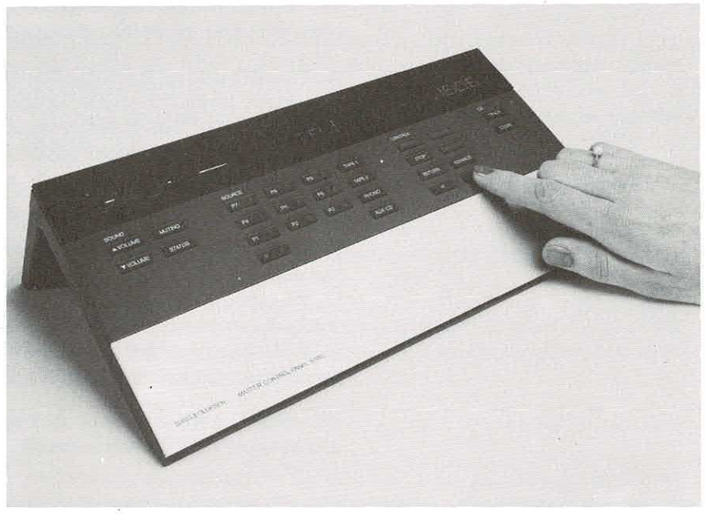
Since the Beogram CD 50 is designed as a component in the Beosystem 5000, it incorporates microprocessor control of all its functions, these being adressable by the DataLINK.

As a result, the Master Control Panel will access any of the players functions including the useful SCAN feature mentioned earlier.

However, as the only CD player in the Bang & Olufsen product range, it is likely to be incorporated with other systems and to this end, an optional remote control Terminal CD 50 is provided which can communicate commands to an IR receiver on the player's display panel.

Interfacing between the players internal digital control circuits and the LINK IR receiver and DataLINK system is achieved by a specially programmed micro-processor in the player.

CHAPTER SIX
MASTER CONTROL PANEL



Introduction

The Master Control Panel 5000 is a sophisticated remote control unit designed for use with the Beosystem 5000. It is battery powered and uses of infra-red light to communicate with the Beomaster 5000. A unique feature is that the communication is two-way. The Beomaster 5000 always returns a 'status report' on all its systems to the Master Control Panel, every time a remote command is initiated.

This is particularly important in the case of the TIMER, where the clock is actually located in the Beomaster but the time display can be seen on the Master Control Panel 5000 during timer programming.

The location of the Master Control Panel 5000 is important since it has to send to and receive signals from the Beomaster. It must therefore be in the same room as the Beomaster, or in a room where an additional Master Control Link has been fitted. However, the system is sufficiently flexible that transmission and reception can be successfully established even by indirectly reflected signals. Experiment will establish the most suitable locations.

More than one Master Control Panel can be used with the Beosystem 5000.

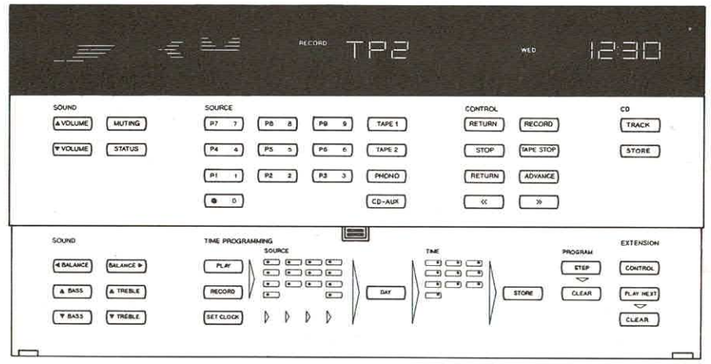
The panel is divided into three areas; the display which shows the system status and the selected programming, the Primary or most used controls, and the Secondary controls which are concealed beneath a hinged heavy metal cover.

The display panel illuminates for a short period of time after pressing any of the control buttons. This conserves the batteries.

A simple printed brief is given of the more complex control sequences on the inside of the metal cover plate.

It is impossible to damage the Beosystem 5000 by mis-operation of the Master Control Panel and so the user could attempt to use the system without referring to an instruction manual. In practice, Bang & Olufsen believe the button layout is so simple, the user will almost always successfully obtain the desired function without resort to the manual.

A description of the operation of each button follows.



Primary Controls

VOLUME: Two buttons with an up and down arrow control changes in the currently stored volume level. An indication of the level selected is shown at the left of the display. On initial switch-on, the Beomaster 5000 will always select the stored sound picture.

MUTING: Cuts the sound to the local loudspeakers. Sound can be restored by pressing the button again.

STATUS: Interrogates the Beomaster 5000 to determine the function in use and the status of the timer and sound picture controls.

SOURCE: Commands the switching of the receiver inputs to the selected programme source. The nine PRESET buttons marked P1 to P9 are used to select previously programmed AM or FM radio stations. The button marked with a red dot and a zero switches the system to STANDBY and resets the Beogram CD 50 to the start position on the disc.

Both the STANDBY and the station PRESET buttons have a secondary function of providing a numeric keypad for entering time programming and the selected tracks on the Beogram CD 50 Compact Disc player. However, they can only be operated in this way when prefaced by operation of either the TIME PROGRAMMING buttons, or the CD TRACK button.

Sources other than the tuner are selected using the TAPE 1, TAPE 2, PHONO or CD-AUX buttons. The latter is intended for use with the Beogram CD 50 Compact Disc Player and when pressed twice or more times activates the PHONO and Compact Disc REPEAT play mode.

CONTROL: Eight buttons located within this group are subdivided into two groups, printed with green or white lettering. All green buttons are used when recording with the Beocord.

RECORD pressed once, checks if the recorder contains a recordable cassette and if the REC OPEN button has been pressed on the Beocord 5000. An indication is given on the display, by a sign reading RECORDING POSSIBLE.

Pressed a second time, the RECORD button initiates recording of the source previously selected. If the TAPE STOP button is pressed a 4 second silence is recorded on the tape and the machine switches to the PAUSE condition. Pressing RECORD will re-start the recording process, or a second operation of TAPE STOP will terminate the recording session.

Pressing the Green RETURN, during recording will stop recording, rewind the tape back to the starting point of the recording session and ready the machine to be switched to record once again. This is particularly useful where a false start has been made and the user wishes to erase and restart the recording session quickly.

The second set of white printed CONTROL buttons provide ways of controlling all signal sources.

RETURN will auto-search the Beocord 5000 or the Beogram CD 50 back to beginning of the track being played and start PLAY again. Pressed twice, the RETURN button will step back to the beginning of the **previous** track, and so-on. ADVANCE performs the same function as RETURN, but in the forward direction.

STOP will pause the Beogram 5000, the Beocord 5000 or any of the previously selected search functions.

The ≪ or ≫ buttons provide FAST FORWARD or FAST REVERSE for the cassette recorder or CD player, or tracking of a Beogram 8002 where fitted.

If the source is the tuner, the ≫ button will switch bands and starting from the lowest frequency, provide AUTO SCAN to the first receivable station or until the STOP button is pressed.

The ≪ button provides the opposite function and switches bands followed by AUTO SCAN from the highest frequency down to the first receivable station. In the AM band, the transition between MW and LW is automatic, the internal circuits providing the necessary frequency jump without stopping the scan.

CD: These two buttons permit programming of the Compact Disc player. After selecting AUX-CD, press TRACK, followed by a number from 1 to 99 entered using the numeric PRESET and ZERO buttons and then the STORE button. The sequence of track selection will be followed on replay.

CLEARing any stored track selection already stored is simple. Complete clearance of the store is done by pressing TRACK followed by PROGRAM-CLEAR in the lower section of the Master Control Panel. Individual stored selections can be cleared by pressing TRACK, the appropriate track number and then PROGRAM-CLEAR.

Track storing or clearing can be obtained whilst in the PLAY or STOP (paused) mode.

All selections are indicated on the display panel of the Master Control Panel 5000 with error messages being displayed where discs or tapes are not present in the appropriate machines.

Secondary Controls

Less used controls such as TONE, BALANCE, TIMER PROGRAMMING and CD player controls are found beneath the hinged metal panel covering the lower half of the Master Control Panel 5000. Once again, they are in three groups.

The first are the SOUND controls. Two BALANCE buttons provide relative level adjustments between the loudspeakers, to the left or the right. BASS and TREBLE up and down controls provide relative adjustment of the low and high frequency outputs.

Indication of the setting of all these controls is shown on the display panel. Five buttons in the central area of Secondary Controls provide TIMER programming of either RECORDing or PLAY from the tuner, cassette recorder or turntable.

To programme select PLAY or RECORD. (Check RECORDING POSSIBLE) Then select, using one of the SOURCE Primary buttons, the desired source. Select the DAY by pressing the DAY button the required number of times. Select the time on a 24 hour clock basis by using the numeric PRESET and ZERO keypad on the Primary Control area. Store the command by pressing STORE.

Further TIMER programmes up to 12 entries can be made and then scanned or cleared using the PROGRAM STEP and CLEAR buttons.

Any of the programmes set can be cleared by STEPping through to the selection to be cancelled and then pressing the PROGRAMME-CLEAR button.

Finally three buttons are allocated for pre-programming the NEXT event. Operating the CONTROL, PLAY NEXT and a source button will determine the programme source the system will select after finishing the playback of a cassette, a record or a Compact Disc track.

CHAPTER 7
THE LINK

Introduction

The individual components of the Beosystem 5000 each contain technical innovations that are significant contributions to improved sound reproduction. Nevertheless, the LINK system which is a more abstract – less obvious part of the Beosystem 5000 is in some ways more important. It is fundamental to the 'human engineering' advances that characterises the Beosystem.

The LINK is an 'intelligent' extension of remote control which started with products such as the Beosystem 2400 and evolved with later products.

In the form found in the Beosystem 5000, LINK is really two complementary communication and control systems working hand-in-hand. The extensive use of microprocessors for signal processing and control of individual system components has permitted Bang & Olufsen engineers to extend and simplify remote control in many novel ways.

The logical starting point was the simple extension of the infra-red remote control system. The Beosystem 5000 LINK provides two-way communication between the remote Master Control Panel and the Beomaster 5000. The addition of a return channel not only allows the system to 'confirm' that a command has been received and acted upon, it also permits an extension of the facilities at the Master Control Panel – the most obvious of which is a digital clock.

In fact, the clock is not in the Master Control Panel at all – it is in the Beomaster which has no display for time at all!

By itself, the LINK and the Master Control Panel would be of limited use unless there was some form of additional communication with the rest of the system. This is achieved by a second element within the LINK concept. Called Data-LINK, it comprises a single wire connection between all the components of the Beosystem 5000 enabling data in digital form to be exchanged between the Beomaster and any other component.

The two parts of the LINK can 'talk' to each other via the Beomaster, enabling it to 'pass-on' commands to the cassette recorder, the Compact Disc player or the turntable from the Master Control Panel or the simpler infra-red Terminal 5000.

The Data Link also offers an additional feature in that any command initiated at one of the system components will be communicated to the Beomaster enabling it to switch sources and perhaps, stop other sources playing.

Although the Master Control Panel has a powerful IR transmitter and can work by indirect reflection, it will not work outside the room in which the Beomaster is located. This has led to the provision of a separate option of a wired extension to the Beomaster's IR transceiver called the Master Control LINK.

This can be located anywhere around the house where the Master Control Panel may be used. Usually, this will be where extension speakers are fitted, in which case, the cabling to the speaker relay box already contains the wiring for the IR Master Control Link.

The digital coding format is common to earlier versions of LINK, so reverse compatibility is assured, enabling several alternative components to be incorporated in the Beosystem 5000, in some cases with an increase in the range of controls offered.

The Beosystem 5000 is the first to offer a CD player as one of the signal sources. This has led to some interesting compromises regarding remote control. For example, as the first of a generation, it is quite likely to be a product which will often be sold in its own right as a component for integration into other audio systems.

For this reason, it is also fitted with an IR receiver, and a separate Terminal CD 50 can be supplied giving direct access to the remote controlled facilities of the player, without the need for the Beomaster 5000.

The hard-wired extension of the Master Control Link meets normal digital communications standards (ttl) and thus represents a possibility for alternative control inputs to the system. For example, with a suitable interface adaptor, a computer could be used to control the many functions of the system, extending remote control to hundreds of kilometers via a computer modem and the telephone line.

This might appear fanciful, and indeed, is only the sort of feature likely to be wanted by electronics or computer enthusiasts, but it does illustrate how the LINK system represents an important stepping stone towards an integrated home management system.

Indeed, if it were not for the relatively high cost of memory integrated circuits, the microprocessors used in the Beosystem 5000 could easily outcompute many of the smaller domestic home computers. To many computer enthusiasts, the parallel between LINK and computer networks will be obvious.

LINK operation

The infra-red LINK between the remote unit and the Beomaster 5000 is rendered more immune to error from interference than in previous systems by defining the zeros and ones of the binary pulse train in the form of bursts 40kHz modulation.

Ones are represented by a burst which lasts for 75 % of the basic timing cycle, zeros by a burst of 40kHz for 25 % of the timing cycle.

A significant advantage of this system is that it has avoided repetitions of a command signal to provide error correction and sets no limit to the length of code that can be sent.