The amplifier evolves

PAUL MESSENGER BRAVELY ATTEMPTS A COMPREHENSIVE APPRAISAL OF THE AMPLIFIER.

The historical perspective gives clues to the how and the why things are the way they are today, which is helpful when change has been as rapid and as sweeping as the fifty or so years of post war hi-fi. Were he or she to step back in time, the current hi-fi enthusiast would be bewildered by the limited resources at his disposal in the forties, as the microgroove (LP) record, compact disc, FM radio, nor tape recorder had yet been introduced. The 78rpm shellac disc and AM radio were strictly mono.

Hi-fi in those days was very much a technical hobby, frequently appealing to the same sort of person who was into amateur radio. And with no specialist hi-fi shops as such, apparatus was almost entirely home built, often using valves and other components from the government surplus stores that gathered around London's Tottenham Court Road and Edgeware Road.

As often as not, the most famous designs of this period existed primarily as printed details of circuit configurations, originating from the valve manufacturers or legendary engineers such as DNT Williamson. Indeed, since much of the 'art' in valve amplifier design was vested in the construction of the output transformers, transformer manufacturers like Partridge were as well known as those who assembled complete amplifiers.

In those early days hi-fi was substantially a hobbyist market, with much of the apparatus home constructed by people who had a fair amount of technical knowledge, and who were also prepared to accept (or impose) standards of domestic acceptability that would be unusual in the majority of homes. Even though the amplifiers were comparatively low-powered and mono, they were big, cumbersome and very heavy, requiring careful housing because of the plentiful heat produced. The high temperatures and attendant heating and cooling also reduced component life and reliability.

Outlandish dimensions gradually shrank with advances in transformer, valve and circuit design, but the advent of stereo in the fifties was a major setback to the domestication of the amplifier, because most of it needed to be doubled up. By this time most designs consisted of two units: the power amplifier/power supply, and the preamp, the latter drawing its power supplies from the former. There was little point in doubling up on everything for stereo, unless one was merely adding to an existing system, so the normal practice became either to control two mono power amplifiers from a single stereo preamp, or to use a stereo power amplifier with both channels sharing a common power supply for economy.

Keeping pre and power amplifiers separate remained de rigeur for the serious enthusiast, as it still is today. But the popular end of the market was moving towards total integration, made feasible by smaller transformers and improved circuit efficiency, though not

without some compromise.

The transistor appears

Thirty odd years ago the typical amplifier still used valves, but had become sufficiently compact that a stereo model would typically occupy less space than the mono equivalent of a decade earlier. The market as a whole had grown considerably, helped by falling real prices and rocketing sales of the stereo LP in the Beatles era, plus the introduction of stereo FM radio, while manufactured product overtook the home-constructed type in popularity.

At least until the last couple of decades, and to some extent still, the hi-fi business has insufficient commercial clout to warrant the high cost of developing its own dedicated electronic components. Most of the devices used are the crumbs from the table of radio, military, computer or telecommunications applications. These are adapted to hi-fi use by the ingenuity of the designers, but long-term developments remain somewhat dependent on the opportunities afforded by the available devices.

When the transistor was invented in 1948, it was in no way suitable for analogue audio use, being fundamentally no more than a convenient electronic switch. However, switches are very important in electronics as a whole, and its potential for reliability, longevity, simplicity of mass production, and low voltage operation, were sufficient to divert nearly all research away from thermionics (valves). Indeed at the end of the forties prototypes existed of low voltage 'cold' valves which might have heralded a whole new generation of thermionics, had not the transistor appeared and usurped the development money.

It was the mid-sixties before the transistor really became a hi-fi force to be reckoned with — and thirty years on it is still scorned by many serious enthusiasts. The earliest transistor amps (like the Leak Stereo 30) certainly didn't match the sound quality of contemporary valve equivalents, but were so much more domestically acceptable that they became a great commercial success.

First and foremost transistor amps run comparatively cool, avoiding the extremes of temperature that valves share with light bulbs, which reduces their working lives compared to transistors or fluorescent tubes. Running cool also allows greater siting flexibility and reduces the need for ventilation.

Second, the transistor amp is more compact and cheaper to make than the equivalent valve amp. Particularly when comparing power for power, mainly because output matching transformers need no longer be used. Leak's Stereo 30 transistorised integrated amplifier was very little larger than the company's valve stereo preamp which was being manufactured at the same time, and which needed to be used with even bulkier power amplifiers. Similarly the 45watt per channel stereo transistorised Quad 303 power amplifier was a similar size to the 15watt mono power amps it replaced.

Third, the transistor amplifier arrived about the same time that the low output magnetic cartridge had established a firm foothold, and the mid-sixties transistor amplifier caused less hum and noise problems than the valve equivalent. Finally, the transistor is much less subject to the gradual ageing process that has always plagued valves, and by and large its performance will not change much over time.

While both manufacturers and customers rushed headlong into the transistor age, hindsight might suggest that this was a case of the deaf leading the deaf. Although it was possible to 'prove' the superiority of the transistor amplifier on paper, many designers had overlooked numerous implications of the sweeping changes they were making. The valve amplifier was the result of decades of careful, painstaking development, so it was perhaps inevitable that the new technology would have its teething problems. It must nevertheless remain something of a tribute to the persuasiveness of marketing techniques that transistors became established so quickly

and with such little fuss — we were after all basking in the 'white heat of technological revolution' around that time (and had already finished 'never having had it so good'!).

This is not intended as an attack on transistor amps per se. Rather it is a cautionary tale to illustrate the unfortunate way that fashion and commercial pressures tend to dominate the hi-fi marketplace, not always in the interests of the consumer. The lesson from history is that a 'breakthrough' in technology usually acts against the best interests of the user first time around, because many of the attendant problems are overlooked. The second and third generations usually turn out to be far safer bets, particularly as lower fashion status also results in a lower price! Witness the introduction and subsequent evolution of CD players.

Undoubtedly one reason the transistor gained its foothold so quickly was that it appeared to offer superior power at reduced price. This was true under test bench conditions, but it was many years before it became accepted that the 'real' conditions of music signal and loudspeaker drive gave the valve amp certain compensatory advantages, particularly when driving near the overload limit, and that the transistor amp probably needed to be twice the power of its valve equivalent in lab terms to avoid running into potentially rather nastier overload problems.

A similar state of affairs was repeated twenty years later in the introduction of the digital compact disc format. This was developed according to technical specifications that seemed more than adequate, and ought to have performed significantly better than the existing analogue formats. In practice, and despite ten years of CD development, top quality vinyl replay remains comfortably superior in important respects. History does indeed repeat itself.

Even though some die-hard enthusiasts might disagree, the transistor amp was a godsend from the point of view of turning hi-fi into a mass market consumer product. And even though the initial steps may have been a little faltering, the end result has been to spread hi-fi to a far wider audience at reduced cost.

The amp receives a rival

At around the time that the integrated transistor amplifier was gaining a foothold, another form of integration known as a receiver was also starting to appear, combining a complete amplifier and tuner in the same case. This combination was particularly successful in the USA, but also did well in Britain at the time because of its compactness and a price saving of about 20 per cent over equivalent separate tuners and amplifiers (thanks to costs saved on power supply, transport and casework etc).

Despite a fair amount of success through the late sixties and the seventies, the receiver almost faded from the scene in the eighties. As the distinction between 'real' hi-fi separates and packaged systems widened, it suffered from a lack of credibility as an 'in between' product, perceived as a compromise by those buying hi-fi separates, yet without the complete package of integration of a music centre (complete with record and cassette decks) or the styling coherence of a stack system.

The receiver never quite disappeared from the UK scene, and has recently started to make a bit of come back via the AV surround sound scene. These AV receivers are rather different animals from their predecessors, due to the extra power amplification and AV processing functions, so comparisons are barely relevant. And the tuner stage in today's receivers tends to be regarded very much as an afterthought, worth less than £50 of the total price and performing no better than those fitted to packaged mini systems.

Ultimately, the receiver lacks flexibility. If one decides to improve either amp or tuner, you really have to change both at once. There's no control over the relative proportions in which the money has been spent

either. As the various products have evolved over the years, so the receiver has fallen quite a long way behind the performance of separate tuners and amplifiers.

Revolutionary times

The mid-sixties arrival of the transistor and the receiver were two harbingers of a major revolution which took the hitherto cozy hi-fi hobby by the scruff of the neck, turning it into a mass market consumer electronics phenomenon in a few short years.

The early seventies found hi-fi sales booming like never before (or since!), almost total transistorisation, a handful of separate pre and power amp combinations and rather more integrated designs, plus a burgeoning of receivers. The quality of the actual electronic devices continued to improve and/or get cheaper, but most of the changes had more to do with fashion and marketing than any particular desire to improve the breed.

With a strong UK market, our domestic manufacturers introduced a number of imaginative and refined designs which continued to try and make the amp as small as possible. However, the market as a whole seemed to equate size with potency, and compaction beyond a certain point gave diminishing commercial returns.

The really crucial change was that Japanese brands, which only started appearing in the mid-sixties, simply took over the UK market. At the beginning of the decade brands like Goodmans, Leak, Armstrong and Rogers were at least on a par with Sansui, Trio, Pioneer, Sony et al. By the mid-seventies Quad was practically the only British amplifier brand left. (Companies like Arcam, Naim Rega and Linn had barely got started.)

It's a classic case history of British commercial bungling, as much to do with government as industry incompetence. Most of the UK companies in the hi-fi market were still comparatively small, specialising in hi-fi, while the larger UK consumer electronics companies, which were active in the radio and TV markets, seemed curiously reluctant to take the hi-fi market seriously. So with one or two exceptions (Goodmans/Thorn, Leak/Rank) there was little spare production capacity amongst the existing manufacturers to cope with a big increase in demand.

The Japanese Yen was standing at more than 500 to the pound, and the cost of labour was low then too. Its electronics industry, already large from international transistor radio successes, discovered that the Japanese consumer was an avid purchaser of hi-fi equipment. This provided a home market

similar in size to the US market or the whole of Western Europe, giving enormous economies of scale and enabling the industry to respond quickly to specific local changes in demand anywhere in the world. The products themselves succeeded less perhaps on the basis of technical or sonic superiority than due to a reputation for excellent reliability, alongside a marketing professionalism which appealed to the less technical hi-fi dealer that was appearing.

It may not be immediately apparent why they achieved such a dominant position so quickly at the expense of so many UK manufacturers, until one recalls a characteristically crass piece of tax legislation perpetrated by Chancellor Healey in the mid seventies, as a deflationery measure in the middle of a consumer boom. The decision to raise the VAT rate on luxury goods, including electronics, to 25% was probably necessary; the decision to allow a month's 'period of grace' before this came into effect was a piece of fiscal lunacy from which the market has never fully recovered. During this month approximately twelve months of normal business was done by seriously harassed retailers. There was no way British manufacturers could react to meet this twelve fold increase in demand, and some merely acquired a reputation for poor reliability attempting to do so. Instead retailers accepted money for goods that hadn't even left the Japanese factories, and most importers emptied their European warehouses (one bringing in three containers of equipment a day).

This extraordinary route to a tax increase pre-empted the best part of a year's business, and it's hardly surprising that the slump which followed almost wiped out the home market, sending many retailers to the wall and killing off several manufacturers who were insufficiently established in export markets to cushion the blow. While the importers themselves also suffered in the aftermath, the slump barely registered back at the giant Japanese manufacturing plants, because for them it was a distant and isolated event.

In the immediate wake of this boom/slump the Japanese asserted an even more dominant influence on the market. However, a number of healthy new small scale home manufacturers have replaced those that disappeared, building upon the fragmentation that became a significant market trend.

The eighties saw the market split into two different camps. Some consumers followed the Japanese-led trend towards greater complexity that was established at the start of the seventies, and which was to achieve its zenith in the quadrophonic debacle of the mid-seventies (about which the least said the better). Others, perhaps in reaction against this overt consumerism, but also because it became increasingly understood that simplicity in the signal path improved the sound quality, opted to go the other way entirely, even to the exclusion of tone controls.

This trend towards simplicity was by no means just a British phenomenon. Mark Levinson in the US as well as Naim in the UK attracted widespread derision by ditching tone controls, yet can now be seen to have set a lead which many others would subsequently follow.

From a 1994 perspective it's difficult to believe that none of the leading British amplifier brands (bar Quad) existed before 1970. Naim and Linn got going at the beginning of the seventies, Arcam, Mission, NAD and Meridian towards the end , while Audiolab, Musical Fidelity, Roksan and Audio Innovations all started up in the eighties.

By the late eighties these small, young British amp manufacturers with their stripped-down, sound quality oriented designs were threatening to take over from the bells-and-whistles Japanese stereotypes. So much so that Japanese brands, led by Rotel and Pioneer, have recently responded with their own 'stripped down' audiophile oriented models at close to mass market prices — and with considerable success.

The late seventies also saw the emergence of a third philosophy, based on rejection of the transistor in favour of a return to valve technology. The initial surge of interest seemed to peter out in the early eighties, but has come back with quite a bang over the past five years in particular.

The status quo today finds a market of considerable and fascinating diversity, well illustrated by those assembled for review elsewhere in The Ear. Sales are still dominated by the integrated, transistorised 430mm wide black box stereotype, but probably one with less features and a lot better sound than its predecessors, and as likely as not with a British rather than a Japanese brand name.

But above and beyond budget and mid-price basics lies a wealth of choice in presentation and performance which covers a much wider range of options than at any time in the past. The evolution of the marketplace itself is proof positive that important sonic differences do exist between rival brands and philosophies of hi-fi amplification, and that customers are prepared to pay a premium for superior sound quality.

The role of the amplifier

There's no doubt that the amplifier forms the heart of the hi fi system. Lose one of the other components and you probably still have a spare source, a single loudspeaker or headphones with which to listen. Lose the amplifier and the system is silent.

Its job, quite simply, is to accept signals from a variety of different sources, process them as required, and then amplify them sufficiently to drive loudspeakers. This is fine as a basic definition, but as soon as one starts to try and define this in engineering terms, controversy begins. Before becoming enmeshed in this, let us look at the sort of things an amplifier is usually capable of doing, and why a particular model includes or excludes these facilities.

Every amplifier consists of three basic 'building blocks', namely the preamp, power amplifier and power supplies. These are normally combined together in the same box and called an integrated amplifier, but some designs, for either technical or fashion reasons, separate them into a variety of separate box configurations.

The preamp section contains the various signal inputs and their switching circuitry, extra signal processing stages (eg vinyl disc inputs and tone controls), plus output signals to feed tape recorders and separate power amplifiers. Having converted the different input signals to a common level, these are volume and balance controlled before being fed to the power amplifier stage.

The power amplifier section's job is to multiply this signal to a sufficient level to drive the loudspeakers (and as a by-product headphones) to the required levels.

However they're packaged, the power supply or supplies are really an integral part of the other components and should not therefore be considered separately at all. Their job is to supply the right amounts of electricity in the right paces — and to do so at the right time.

The preamplifier

The modern amplifier has to accept signals from a wide variety of different sources, nearly all of which put out approximately the same sort of output, known as a 'line level' signal. The one exception is the vinyl disc record player's pickup cartridge, which requires very different and much more elaborate preamplification, including considerable extra gain and complex equalisation (see page 36).

Now that CD has supplanted vinyl as the prime source for many hi-fi users, a number of amps and preamplifiers which leave the vinyl disc stage out altogether, or offer it as an optional extra at a higher price, are appearing. However, a line-only amplifier doesn't preclude the vinyl option, due to the growing availability of separately packaged (and power supplied) dedicated vinyl disc stage only amplifiers, whose sole task is to

convert the output of a pickup cartridge to the necessary level and characteristic for any preamp line input.

What this means is that the preamp's main function is now simply to select between a number of inputs and provide volume and balance control. Some enthusiasts have adopted the extreme purist approach of making the entire operation passive (ie unpowered), using two top quality volume controls (one for each channel) and high class switches, in order to keep the input signals as clean and undisturbed as possible en route to the power amps. This minimalist approach is a godsend to those who like to roll their own hi-fi, and has a strong philosophical appeal to the purist, but flexibility is limited and results can vary somewhat unpredictably according to the other components used in the system.

The opposite side of this coin is the increasing availability of remote control operation among the current crop of amplifiers on the market. This is spurned by purists, and difficult for the smallest companies to implement. But we've all become so used to remotely controlling video recorders, television sets and CD players that to have to get up to change volume or select an alternative input seems to become increasingly and unacceptably tedious.

Although hi-fi enthusiasts seem to prefer the minimalist approach to preamplification, and are happy to sacrifice flexibility and convenience for the sound quality benefits of simplification, there are plenty of models around which offer various extra functions and features to tempt those who prefer to buy with their eyes rather than their ears.

Although multi-band equalisers have never achieved much popularity here in Britain, remaining a largely American phenomenon, basic bass and treble tone controls are still fitted to the majority of amplifiers. However, the high quality of modern source signals often renders them redundant for much of the time, while their inclusion costs money and tends to compromise quality at the same time.

Vinyl disc replay

The vinyl disc pickup input should be designed around the signals it receives from a cartridge. Until the mid seventies this was almost invariably a moving magnet (MM, also known as a high output) type, with a typical output level of 1mV/cm/sec, responding to the disc modulations in a velocity sensing manner.

Understanding those last two technicalities is not really necessary: their implication is that most cartridges produced a similar output from the same record, and that it is necessary to process this output by changing its relative level at different frequencies, because of the way the disc cutting is pre-emphasised to get the information on in the first place. (If this equalisation process was not carried out, the sound would be all top, treble, and tizz, with no bass.) Happily a 'standard' weighting curve exists for this transformation, known as the RIAA equalisation curve.

The fly in the disc input ointment, however, is the moving coil cartridge (MC or low output in the jargon). This normally produces a much lower voltage output than the moving magnet type, and consequently needs special treatment. To confuse the issue there are a number of high output MC cartridges about which are intended to work normally into any standard MM type phono input; but the majority, however, need about 20dB of extra gain.

This is often available within the preamp section of the amplifier, either as an addition or alternative to the standard MM phono input. Valve preamps rarely attempt direct amplification of low output moving coil signals, because of noise problems, preferring instead to use a booster/impedance matching transformer to bring MC up to MM levels.

Since the mid-eighties dawn of the digital CD age there's been a small but growing trend

towards preamplifiers with only line-level inputs — and a complementary supply of standalone phono stages to fill the vinyl replay gap, often with considerable effectiveness. It's slightly ironic that the last dozen or so years has seen top notch moving coil phono stages incorporated into and then gradually moved out of high end preamps; a full analogue circle.

The very nature of the phono cartridge is a mechanical miracle that has no right to work at all, and succeeds in doing so by mechanical wizardry that has placed the two major unavoidable 'resonances' outside the audio band. A resonance is, basically, a mechanical loss of control which will be reflected in the electrical output. The major difference between the pickup and the other types of signal an amplifier has to deal with is that neither the bandwidth, nor the behaviour outside the required bandwidth are accurately known or predictable. The preamp has to cope with resonances beyond the audio bandwidth in both directions, ie infra and ultrasonic.

Until fairly recently most moving magnet cartridges incorporated an automatic HF roll off, due to an electrical filter caused by the resonant interaction of their internal inductance and resistance with the resistance and capacitance of the arm lead and pickup input. Placing such a resonant circuit at the top end of the audio band isn't a very good idea from a sonic point of view, but it does at least ensure that the amplifier's disc input doesn't receive any potentially embarrassing ultrasonic signals.

For a number of reasons, mostly to do with improving sound quality and performance predictability, many of today's cartridges — including, by definition, all moving coil types — are low inductance types. A good amplifier may well sound better when fed such a wide bandwidth signal, but the vinyl disc stages of budget models tend to be more unpredictable and compromised.

The phono input of an amplifier therefore has a number of potential troublespots. It requires heavy equalisation and much more gain than the other inputs, particularly for moving-coil cartridges; certain input parameters (such as impedance and capacitance) are not standardised, and yet can affect the performance of the system; and the absolute content of the signal in terms of bandwidth and amplitude is not precisely known, which could cause overload or slew limiting problems.

Tape in/output

Cassette tape recorder should be connected to the amplifier so that it can replay tapes via the system, and also record any of the signals being fed into the amplifier's other inputs, such as tuner, CD or vinyl disc — an added complication which can become quite confusing, especially if two tape decks are in use, and dubbing between them is required. The tape deck therefore needs four leads

instead of two: one pair carries the record output signal from the amplifier; the other the replay signal back to the amplifier.

There are a number of different ways of doing this, but by far the most common links the record output signal to the amplifier's input selection switch. If CD is selected, then the signals from the CD player are sent to the recorder as well as being amplified. The record out signal is taken off prior to the volume and tone controls of course, so you can still listen to the system at whatever volume you like while sending a consistent level signal to the recorder.

Some of the more upmarket cassette (and reel-to-reel) decks have a very useful feature called off-tape monitoring, which allows the quality of a recording to be checked while it is actually being made — a very handy way of avoiding later disappointment. To accomodate this feature, most amps use a 'tape monitor' switch, separate from the main input selector and often a simple pushbutton. Selecting tape monitor mode overides the input selector so that the amplifier reproduces whatever is coming into the tape input sockets instead, though of course the input selector setting is still reponsible for determining which source is being sent to the tape recorder.

CD input

Increasingly the most important input on a preamp these days is the one marked CD. In basic terms this is merely a line input like any other, and can indeed be just that. But because CD is the prime source for many hi-fi users, various extra precautions are often used to extract as much as possible from this particular input.

The search for the ultimate CD sound quality has led many audiophiles to experiment with ditching the normal powered preamplifier altogether, in favour of a passive (unpowered) preamp which merely consists of volume controls, selector switch, inputs and outputs. The advantages and disadvantages of passive or active preamplifiers are the subject of fierce debate in esoteric hi-fi circles. There are even those who claim that using active preamps with integrated amps can improve matters. The answer probably depends upon the characteristics of the rest of the components in the system, and the personal taste of the user.

What is certain, however, is that there's rather more to a line input than appears on the surface, a fact proved by the variance in sound quality and price of line preamplifiers. Various factors affect the sound of line inputs but the primary ones are circuit design and topology, component quality, switching facilities and the amount of gain applied. Component quality is obviously a major factor influencing the price, but the other elements are down to the designer, and these are what create the sound differences between similarly priced products.

Volume control

The most important control on the preamplifier adjusts the volume level. So it's ergonomically desirable that it's easily accessible and readily identifiable. It's also important that volume can be adjusted over a very wide range, without significant shifts in channel balance.

A curious and totally unfounded myth seems to have spread amongst those who normally have little to do with hi-fi, to the effect that the power of an amplifier is in some way related to how far round the scale the volume control needs to be for normal listening levels; I have even encountered people who have criticised an amplifier for needing to have the volume control above halfway!

If an amplifier has already reached the point of delivering full power from a specific signal when the volume control is only halfway, increasing it above this point will only drive the system into distortion. The second half of its travel is therefore entirely wasted while the usable part of the range is

unnecessarily cramped, and a small amount of movement results in an undesirably large 'jump' in volume.

The ideal volume control should cover a range of at least 60dB, and do so evenly in order that similarly sized rotational steps result in similarly sized changes in volume. Many of the potentiometers used for audio volume controls can manage fine at the higher volumes, but are frequently too sensitive at the lower levels, so that a slight movement gives too large a change for accurate setting. Moreover this can give problems in maintaining accurate channel balance at very low levels. It is fashionable in some parts to use volume controls which mimic the action of professionally used 'attenuators', so that their operation consists of a series of steps. Cheap detent-action potentiometers which merely add a mechanical cogging action to a conventional continuous potentiometer can be a real pain, often making problems that can be heard at low volume levels significantly worse. Proper hard-wired pro-style switched attenuators are probably the best technique of all, but they're very expensive and rarely found on commercial products.

One useful technique that has been used to extend the operating range of a potentiometer is to combine it with a switchable attenuator that offers one or two positions of muting or quieting, typically subtracting 20dB from the operating level. As well as helping to 'stretch' the low level area of control, this feature is quite handy when, for example, answering a telephone or addressing a spouse. This type of mute switch can therefore be a useful part of a volume control, although its greatest benefit will be conferred when the volume potentiometer itself is a fairly cheap device; a really good full range control (necessarily expensive) renders it much less necessary, and arguably an undesirable addition on purist sound quality grounds.

The balance control

The final almost-essential is the balance control. This is required to adjust the relative loudness of the two stereo channels, which can be useful in a number of circumstances. It's not likely to be needed very often, and some purist designs leave it out altogether, but it can be handy in various roles: compensating (more or less) for an off-centre stereo listening seat; making some allowance for speakers which are not the same distance from the listener; compensating for a poor output match between the two channels of a stereo cartridge or two loudspeakers with slightly different sensitivities; and compensating for volume control 'mistracking' (ie channel balance shifts), especially at very low volume levels.

Most balance controls are able to quieten completely one or other of the channels at their extremes of travel, which can be useful when checking for system faults. A great many balance controls are also fitted with a centre-indent, which 'clicks' at the centre position.

Other inputs/outputs

Manufacturers frequently offer a number of other inputs and outputs to increase the versatility of their machinery. The value of these will depend very much on the complexity of the installation in which the amp is to be used. The switching for connecting tape recorders or extra inputs are available as accessories which can be added later if desired, so those who may be concerned about the future expansion of their system, and hence the provision of unnecessary amplifier inputs, really have very little to worry about.

The switching used to connect and cross-connect two tape recorders might be useful, since many people have probably now accumulated more than one recorder. However, in practice the full cross-connect flexibility is often unnecessary, since only the better of two decks is likely to be used to record from the other, while those who plan to do lots of tape copying are probably better off opting for a twin-transport cassette deck. Cross-

dubbing is normally accomplished using an extra five-position rotary switch, which does add to the complexity as well as versatility of an amp.

Another tape routeing method allows the signal being sent to the recorder to be different from the one which is being replayed via the loudspeakers. This has parallels with the way a video recorder allows one to record a second channel while watching the first, and could be useful as a 'time-stretch' mechanism, for example, enabling a radio broadcast to be saved for later while you're spending the evening playing records.

A final input/output that is sometimes fitted to the more expensive integrated amplifiers is a 'break point' between pre and power amp sections. These usually comprise two sets of phono sockets, either physically and electrically connected by metal rods, or controlled via an adjacent switch. This allows the integrated amp to be regarded as a separate pre/power combination in all but siting flexibility, with the possible advantage that certain accessories can be inserted between pre and power amp stages if desired.

DSP

Rarely yet found on serious hi-fi stereo amplifiers, digital signal processing (DSP) techniques are used extensively in multi-channel AV amplifiers and processors. Either as part of the decoding of movie soundtrack surround information, or to emulate the acoustic characteristics of certain environments and generate surround sound effects.

When used in the context of multi speaker surround sound set-ups the DSP effect can be quite striking, though whether it furthers the state of the art or even enhances the listening experience with purely music sources is open to debate. It's interesting to note however that several fairly serious hi-fi companies are experimenting with DSP, and obviously feel that there is some scope for increasing standards of fidelity. What's more, unlike CD, it's not restricted to a particular standard.

The power amplifier

The power amplifier has the supposedly simple task of driving the loudspeakers with the signal it receives from the preamp. To examine and discuss some of the ideas involved, it is first necessary to understand a little about what electricity consists of and how it behaves. We're not about to launch into a jargon-ridden treatise on electronics, but a brief examination of the relationship between electricity and hi-fi will help establish a perspective on some of the controversies surrounding amplifier design.

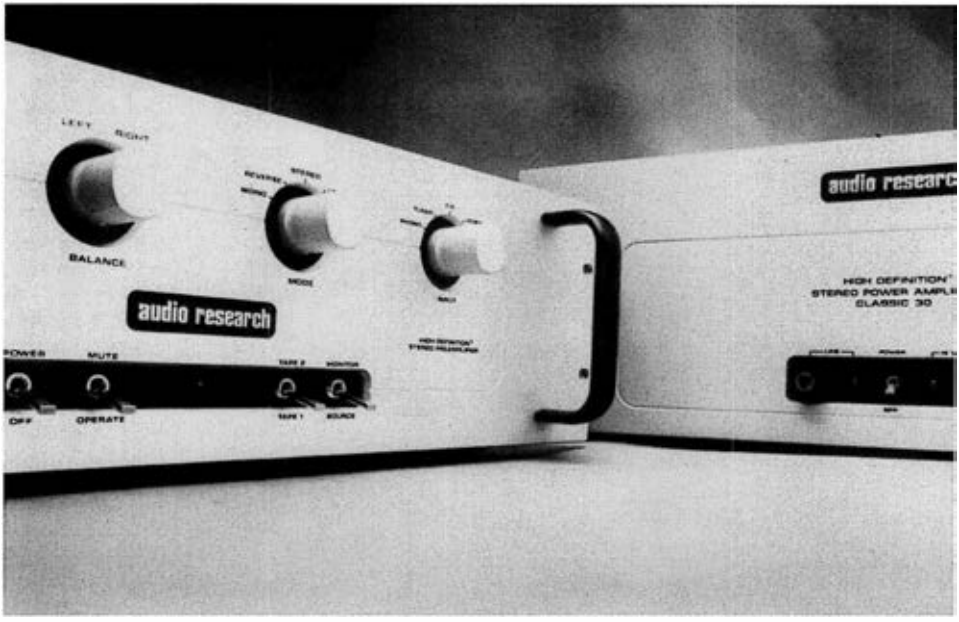
Electricity is concerned with the movement of sub-atomic particles called electrons within a conductive medium, which is usually a metal. The engineering discipline of electronics is basically concerned with controlling the behaviour of electrons by manipulating the medium in order to carry out all manner of complex tasks, some of which are concerned with hi-fi reproduction and transmission.

Hi-fi is all about the storage or reception and reproduction of sound, and sound is a vibration in the molecules of the air, with the size (amplitude) of the vibrations corresponding to volume, and their frequency (number of vibrations per second) to the pitch of the sound. One of the most useful techniques in this task involves making a model of these air vibrations in the form of electrical vibrations — hence the microphone converts the movement of the air into a movement of electrons via a diaphragm. The reason electricity and electronics are used for this purpose is merely that their technology is the most suitable; one could probably derive hi-fi systems based on entirely mechanical systems like the early 'pre-electric' gramophones, or even use fluidics; electronics is merely the easiest medium in which to work.

Household plumbing provides a good example which helps explain some basic electrical concepts (although the parallel should not be taken too far). When water flows through a tap, two considerations (or 'param-

eters', to use a little scientific jargon) determine the rate at which the water flows. One of these is the force or pressure with which the water is being pushed, which corresponds rather neatly to the voltage in an electrical system; the other is the size of the outlet

The analogy becomes rather more hazy when considering how one actually uses electricity. Water is drawn by turning a tap so that the water flows, impelled by the pressure at a rate which also corresponds to the size of the orifice. One 'draws' electricity by



through which the water flows, and this corresponds to an electrical circuit's resistance. The actual rate at which the water is flowing (current) depends on both the pressure (voltage) and the size of the opening (resistance), and one can cut down the flow from a tap by either turning it off a little (increasing resistance), or alternatively by adjusting another tap which is part of the same system, as this often shares the total pressure available. It also explains why an upstairs bath may not run water any faster than a downstairs sink despite having a larger tap (ie lower resistance): its extra 'current' capability is offset by a reduced 'voltage' (pressure or head of water).

completing a circuit so that a voltage difference is set up across a resistance, and this impels the current to flow, the amount depending on the voltage and the resistance according to that tried and trusted relationship, Ohm's Law. The resistance is frequently a heating coil (to provide heat or light) or a motor (which adds a few complexities that are not really relevant here yet).

With the more complicated alternating signals used in audio, the simple concept of resistance becomes the more complex impedance, which includes two rather more awkward loads known as 'capacitance' and 'inductance'. These are similar to resistance, but their behaviour depends on the signal-

frequency, and they have peculiar effects that are rather like storing the electricity for brief moments, in the way that a spring can store mechanical energy. This has the effect of throwing the voltage and current cycles out of phase (out of step) with each other. While these complex loads make the situation much more difficult to understand, it's actually just as well that they exist, because much of electronics is based on tinkering with their properties.

So far we have examined electricity rather than electronics, yet the distinction is an important one. Indeed confusion is created because certain aspects of hi-fi engineering involve electrical engineering, while others are rooted in electronics. In a nutshell, electrical engineering is concerned with using electricity as a form of energy; electronics is to do with using its properties in, for example, signal processing and control functions.

Electrical energy is concerned with quantities, so the electrical current is as important as the voltage, but with electronic signal processing current plays a minor and usually quite insignificant role; the signals are normally modelled by the voltage, and the circuitry is kept at high impedance to avoid the inconvenient heat and magnetic fields that large currents generate.

However, to get down to power amplifiers at last, their essential task is to deliver energy to the loudspeaker, in order to recreate the audio signal from the 'voltage model' that has been passed through from the preamp. Ensuring that the output voltage corresponds to a magnified version of the input voltage without significant distortion is the part of the problem that attracts most attention, because it is in the more familiar field of electronics, and because voltage is much easier to measure than current.

Having presented this voltage to the loudspeaker, it's the speaker which decides how much current must be supplied at any instant in time. And the current which is drawn will correspond to the instantaneous voltage and impedance at that time. Here we encounter some controversy between designers, over exactly what the impedance of a speaker is, in order to decide what the amplifier has to do to drive it accurately.

Those who read the loudspeaker reviews in Hi-Fi Choice will be aware of curves which show the 'modulus of impedance' of the loudspeaker, as a function of the different frequencies it is required to handle (typically from 20Hz-20kHz). Although this 'modulus of impedance' does to some extent represent the resistive load of the speaker, and hence the current that will be drawn in response to any particular voltage, it is also an oversimplification which doesn't take full account of out-of-phase capacitive and inductive components. Nor is any allowance made for the dynamic, transient interaction of speaker and amplifier under complex music signals, an area which is still only partly understood.

Power supplies

Many successful amplifier designers consider that power supplies comprise the most important single part of any design. Indeed one could describe an amplifier as a power supply connected to a loudspeaker, with the audio signal processing controlling this supply rather like a tap controlling a flow of water. A variety of different design approaches exist, but like most things audio, the 'feature' is less important than the appropriateness of its application. There is no single 'right way', merely a variety of available techniques, whose effectiveness is probably pretty closely related to their price.

The problem with power supplies is that when you remove power from them, you reduce their ability to deliver more power. A slight drop in power capability may not matter in a household domestic electricity supply, where one is only interested in drawing 'crude' power from the system. But audio power corresponds to an extremely complex and subtle musical signal, so any shortfall will show up as a form of distortion

in the signal. A power supply that is fairly impervious to such undesirable effects is often referred to as 'stiff'.

It is therefore quite likely that two separate supplies (one for each channel) will be better than one, all things being equal, because the demands on one will be unaffected by the demands on the other. However, in practice all things are by no means equal, and a number of other factors come into the picture. The most important is that two supplies will inevitably cost nearly twice as much as one. Furthermore, music consists of peaks rather than averages, and the smaller separate supply may be less capable of providing voltage or current peaks than a bigger shared supply.

The twin power supply may offer certain advantages in reducing interference between channels, but is also likely to reduce the peak power capability of the amplifier. A similar result to 'twinning' may be obtained by 'regulating', which involves controlling the output of the power supply by electronic means. This again effectively gives separate power supplies, although only one transformer is used, but again the peak capabilities are lower than they could be with a similar unregulated supply, so a higher capacity will be needed to obtain equivalent peak performance. There's also the extra cost of the regulating circuitry to consider.

The power supplies' functions are to provide the required current and voltage at every stage of the amplification, in such a manner that all points of supply remain independent and do not influence each other. The big question mark remains over that word 'required', and here we come back to the points made earlier concerning possible unknowns in preamp current handling and loudspeaker transient current requirements. Those designers who emphasise both the subjective performance of their amplifiers and the importance of their power supplies tend to try to increase the independence of the different stages, their current handling capability, their internal control, and the speed at which they can supply both voltage and current.

Reviewing amps: the pitfalls

There is no component more difficult to evaluate than the amplifier. Two quite opposite schools of thought exist among designers, the problems coming down to choosing the criteria that are relevant for design or evaluation. Here the reader will have to make some effort to establish his or her own criteria, rather than merely taking the reviewer's, or his critic's, word for it.

These opposing stances are so dissimilar and strongly held that there can be no consensus approach to deciding what makes an amplifier, broadly speaking, good, bad or indifferent. The 'objectivist' point of view claims that any reasonably designed amp that is operated within its limits (of power capability into the accompanying loudspeaker impedance) will sound indistinguishable from any other, provided sufficient care is taken to match levels and ensure that there are no frequency response anomalies.

Close to this extreme position are many others who consider that as the measured distortions introduced by amplifiers are so much lower than those produced by other elements in the chain (notably loudspeakers), any marginal differences between models will be irrelevant. The implication is that the only valid criteria for a sensible approach to purchasing an amplifier is its power capability in relation to price, one's loudness requirements and loudspeakers, and the features and facilities that are needed.

The alternative, and increasingly accepted 'subjectivist', stance proposes that amps are a long way from perfect, and that their performance exerts a powerful influence on the overall sound quality of a system. It is also implied that our present measuring techniques are unsuccessful at revealing important audible differences.

If one accepts this point of view, the criteria of power capability and facilities should be

extended to include listening tests. Furthermore it is also suggested that comparable power ratings may not yield similar maximum tolerable loudness levels, and that a 'loudness capability' is a more valid or useful criterion than measured power.

The essential difference between these points of view is that one places importance on listening tests, while the other regards their results as figments of either the imagination or inadequate test procedures. The situation remains controversial because current methods of subjective assessment tend to be unreliable, while objective measurement techniques cannot be relied upon to give results which properly correlate with claims for sound quality either.

Choosing and using an amp

How does one set about choosing an amp from the plethora of models available these days? At first sight the prospect is daunting, but providing one doesn't simply panic and pick up the first pretty one to catch the eye, it's not difficult to cut the list down to size. The first thing is to decide on a list of priorities, start getting down to a shortlist, and finally do a little listening for yourself to make sure you like the end result.

For most people the first criterion will be price. But having decided on a price, bear in mind that a little less money spent on the amp could leave a little more for the record deck, and you may prefer the overall result; alternatively a more expensive amp with cheaper speakers may be more to your liking. So go for a price bracket, but keep flexible, and try to listen to the cheaper and more expensive options at least to find out what you are gaining or losing.

Price is, however, not the only criterion; for many people the big question will be 'how powerful?' Provided one is reasonably careful, it is probably true to say that there is no such thing as too much power, but addressing three questions will give a more useful and meaningful answer.

How loud do you like to play music? How large is your listening room? How sensitive are your loudspeakers? The first will depend on personal taste; the second on circumstances, so we may as well consider an average room of say 80 cubic metres; the third can have the most marked effect of all.

Across the broad range of available loudspeakers in one of our surveys there can easily be a difference of as much as or more than 10:1 in the amplifier power needed to achieve the same level of loudness! So if you have very sensitive speakers, you should be able to get loud levels in a normal sized room using only a few watts of amplifier power, while the less sensitive designs may need as much as 40 watts to achieve a similar level.

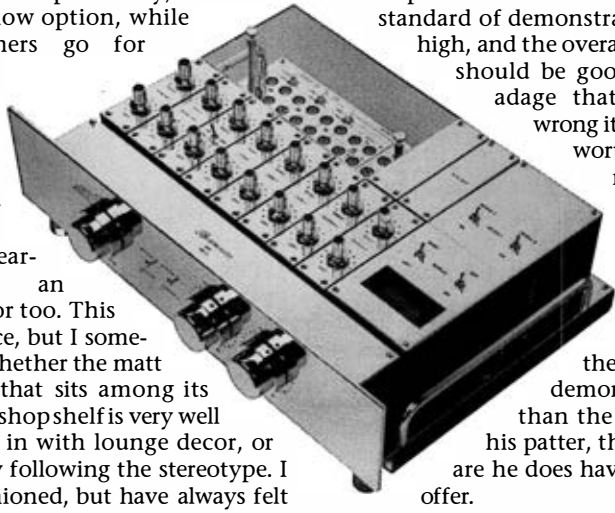
This in turn means that lower sensitivity speakers will be working an amp rather harder, and will leave less in hand to cope with peaks (which can be much higher than the average power levels in music). Fifty watts or so is likely to leave sufficient in hand for the 'average' situation, but if sensitive speakers are used 20 watts may be more than ample.

If you start to find even more powerful (100 watts per channel or more) amplifiers beginning to strain with insufficient 'headroom', using more sensitive speakers will usually be a cheaper way of getting a higher loudness capability. Once again there is no substitute for listening to a combination for yourself to determine whether it is loud enough or tolerable at higher levels; simple specifications give no reliable indication of whether a combination will sound good at high levels.

When choosing an amp it obviously makes sense to check that the inputs provided are going to match your other equipment adequately, and the outputs for tape, headphones, and, most importantly, loudspeakers likewise. Genuine input incompatibilities are fortunately very rare, and usually it's sufficient to ensure that there are enough line level inputs to allow for some future flexibility if the need arises.

However vinyl disc users should take a little

more care to ensure that the amplifier input provides a good match for the chosen cartridge (or vice versa). In the first place cartridges fall into two main groups, high or low output (sometimes referred to as MM or MC respectively). Most vinyl ready amps cater for the high output variety, some offer the high/low option, while others go for either/or, sometimes with the ability to make internal adjustments if requirements change.



Physical appearance is an important factor too. This may be prejudice, but I sometimes wonder whether the matt black monster that sits among its brethren on the shop shelf is very well suited to blend in with lounge decor, or merely slavishly following the stereotype. I may be old fashioned, but have always felt that discretion was the better part of styling, particularly with something that one has to live with day in and day out.

It therefore seems a pity that the average customer gets little alternative to 430mm width and bible black finish — though to be fair, few attempts to break the mould have been notable commercial successes. However, the more adventurous will find that British manufacturers, most of whom are small enough in scale not to be designing for a global mass market, offer a much wider variety of different styles and finishes than the larger Japanese brands.

The final and in our view overriding criterion must be sound quality. We have done our best to give advice on this aspect of an amplifier's performance, but this is a tricky field. We do feel that no hi-fi product should be purchased without prior demonstration, and that the customer should ideally be afforded the opportunity of a home demonstration with the chance to compare one or two alternatives.

A good dealer should be able to demonstrate an appropriate improvement if he tries to sell you an expensive amplifier instead of a cheap one. If a dealer is a good one, his standard of demonstration should be high, and the overall sound quality should be good; another old adage that 'if it sounds wrong it is wrong' is also worth keeping in mind. Above all have a little faith in your own powers of discrimination; if a dealer can sway you by the standard of his demonstration rather than the smoothness of his patter, then the chances are he does have something to offer.

In conclusion a few 'don'ts' when using an amplifier. Don't economise on cables; speaker and interconnect cables are an intrinsic part of the signal path, and it can be worth spending as much as ten per cent of the total equipment cost on them to achieve a system's full potential. In some instances (eg Naim) the amps are designed to work with a specific cable and it would be foolhardy not to use that cable. Don't unplug inputs or outputs while the amp is switched on — this is just asking for trouble; if you have been playing around with the inputs or outputs for any reason, then switch on afterwards at a low volume setting and increase this slowly while making sure nothing is wrong. Don't overdrive the amp for long periods; overdriving is usually easily detectable by an increase in distortion, and if you keep it up for a long time you may well damage the amp or the speakers.