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Oscillators
Theory of the operation of oscillators. Single-ended oscillators. The
transistor oscillation. Use of audio-output tube as an oscillator. Push-
pull oscillators. Oscillator frequency. Coupling the oscillator to the
record and erase heads. Control of bias current. Optimum amount

Record-level indicators
The VU meter. The volume indicator. Vurm type indicator. The
electron-ray tube. The neon lamp. Mechanical vs. electronic indi-
cators. VU meter circuits. Volume indicator circuits. Peak-reading
meter. Full-wave vs. half-wave rectifiers. Loading distortion. Calibrat-
ton of record-level indicator. Circuit location.

Minimizing noise and hum
Sources of noise. Frequency range of noise. Thermal noise. Tube
Reasons for hum pickup. Combating noise. Reducing noise. Combat-
ting hum. Magnetic shielding. Hemis–cathode leakage. Dc heater
supply. Techniques for minimizing hum.

Index
This book is intended for the audiophile as well as the technician interested in the tape recorder; for the audiophile who wants to know "what makes it tick" and for the technician who wishes to approach a tape recorder not only with instruments and a schematic but also with a secure understanding. Comprehension of the factors that enter into the design and operation of a tape machine enables a purchaser to select wisely from the available units and to obtain the best possible recording results; it enables the service technician to insure that a tape recorder yields the performance designed into it.

It is assumed that the reader has an elementary knowledge of electronics and audio such as may be readily acquired from some of the popular and readily assimilable books on the market. If he has a rudimentary understanding of electricity and magnetism, of audio terminology and the fundamental building blocks of electronic circuits—resistor, capacitor, inductors, vacuum tubes, and transformers—he is equipped to follow the discussion. Even the reader who lacks this background should find much that gives him a clearer picture of what is underneath the surface of tape recorders.

In substantial part, the book is written from the design viewpoint. It should be quickly added that this is not a text for designers of tape recorders. Rather, it seeks to explain circuitry in
terms of what the designer is trying to accomplish. To the extent
that circuits are analyzed in certain chapters, the purpose is not
an exercise in circuit analysis but to uncover fundamental prin-
ciples. A grasp of principles will equip the reader to understand
many more circuits than these pages hold room for.

To understand the tape recorder it is not enough to comprehend
the basic ideas at work. It is necessary to examine the problems
that have led to their evolution. The problems remain latent and
rise to plague the user or technician when the tape recorder mal-
fuctions because of wear, misalignment, abuse, etc. Stated dif-
finitely, it is desirable to know not only what makes a tape re-
corder work satisfactorily but also what makes it work unsatis-
factorily.

Side by side with electronic problems there is the ever-present
question of cost. Economy generally dictates the course that the
designer must follow. A given electronic problem may have sev-
eral solutions with varying degrees of merit, but cost may prevent
the designer from using that which he considers best. Here, then,
is one of the most important factors accounting for substantial
differences among tape recorders. In a rough way, one may dif-
ferentiate between “moderate-price” tape recorders on the one
hand, selling for less than $300, and professional and semi-pro-
fessional units on the other hand, priced from $300. The follow-
ing chapters attempt to give due space to each class of recorder.
As a means of directing attention to good practice, the discussion
is likely to focus somewhat more on the circuits and principles
exemplified in the better units.

An appreciation of tape recorder problems, principles and prac-
tices is not a matter of mere academic interest. There are very
practical advantages to such knowledge. The reader can expect
this knowledge to serve him well in extracting the best possible
performance from his machine. Moreover, many a technically
minded audio hobbyist eventually becomes concerned with the
design viewpoint when he finds himself dissatisfied with some
function, circuit or facility of his recorder and wishes to improve
upon it, possibly to the extent of rebuilding a substantial portion.
Here one may draw a parallel with the extensive alterations which
audiophiles perform upon such equipment as audio amplifiers
and preamplifiers. Numerous articles have been written on
changes intended to improve the performance of these units. As
the audiophile grows more at home with the tape recorder, he
may similarly wish to try his hand at improving its performance.

In the interest of maximum clarity, mathematics will be

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avoided as an explanatory device, with very few exceptions
where no more than elementary arithmetic is used to make an
important point clear. In most instances, the discussion can be
offered in common-sense terms. Where only mathematics of a fairly
high level can prove a point, the reader’s acceptance of an un-
proven statement will have to rest upon his confidence in the
author.

The term amplifier, tape amplifier, record amplifier and play-
back amplifier will appear frequently. To avoid possible mis-
understanding, it should be made clear at the outset that these
do not include the audio power amplifier often found in tape
recorders, particularly in moderate-price machines. Explicit use
will be made of the phrase “power amplifier” when the discussion
is concerned with this item.

Scope of the book

A tape recorder consists of two basic parts—mechanical (the
transport mechanism) and electronic. This book is concerned
with the latter, the term being used here in a broad sense to in-
clude everything other than transport. The subject of transport
is sufficiently important and complex that another volume would
be required to do justice to it. Therefore, only a cursory review
of the functions and elements of a transport mechanism will be
attempted. To the extent that the transport creates problems of an
electronic nature—for example, noise on the tape—due attention
shall be paid to it.

It is difficult to draw a clear physical line between the elec-
tronics and the transport. Certain electronic elements are often
mounted on the transport so that electronic and mechanical func-
tions may be controlled simultaneously, or for other reasons.
And, of course, the heads are mounted on the transport mech-
anism. It should be explicit from the viewpoint of this book that the
electronics includes not only the amplifier but also the heads
and the tape.

The various chapters are concerned with the electronic func-
tions of the tape recorder, why these functions are called for and
the means of performing them. To provide perspective, the re-
corder is first pictured in concept, that is, as part of a complete
audio system. Behavior of the heads and the tape is examined.
The fundamental problems of frequency response, distortion and

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Since the preamplifier is an integral part of the amplifier, it will not be considered
as a separate unit. The term amplifier will be understood to include preamplifier.
noise are dealt with in terms of design and of extracting optimum performance from a given recorder. Requirements for high-quality performance are given. Basic circuitry is described and evaluated.

There are many special types of tape recorders, such as those used for industrial testing, electronic computing, scientific measurement, video recording, motion-picture recording, etc. No attempt is made here to cover these, which merit extensive but separate discussion. The fundamental concern of this volume is with tape recorders, either of the professional or moderate-price variety, commonly employed for audio recording and reproduction, especially in home music systems. All tape recorders share certain common principles so that the present discussion is of value to the reader interested in tape recorders used outside the field of audio.

In dealing with a subject such as the tape recorder, it is possible to expand in many directions. Thus, one could write on the nature of sound, on music, on the manifold uses for audio tape recorders, on the art of tape editing, on microphone techniques. These topics are not covered here. Not that they lack importance, but it is the desire of the authors to concentrate on the purpose at hand, which is to explain the electronics of the tape recorder.

In this book the authors seek to explain how tape recorders work, how desired objectives are attained through appropriate design. They have been very conscious of the practical side of the matter and have focused more on recorders as they are than as they ought to be. As a result they have acquired a debt of gratitude to various manufacturers who have supplied schematics, photographs, charts, and other materials for this book. Among these are Ampex Audio, Inc., Audio Devices, Inc., Brum Electronics Company, Conertone [American Electronics, Inc.], Dynamo Magnetronics Corp., Magnecord, Inc. [Div. Midwest Instruments Co.], Minnesota Mowing & Mfg. Co. [A.M.C.], Presto Corp., Presto Recording Corp., Share Brothers, Inc., Viking of Minneapolis and Wilcox-Gay Corp.

Although the entire text of this book is new, the authors have depended in several sections upon materials appearing in magazine articles previously written by them. Accordingly they wish to thank Audio and Radio & TV News for permission to use charts, tables, and other data which appeared in these articles.

Herman Buxstein
Henry C. Pollak