A STUDY CONCERNING TRAINING MATERIALS RELATING TO THE REPAIR OF CASSETTE TAPE RECORDERS

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Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1974

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1978

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TO THE REPAIR OF CASSETTE
TAPE RECORDERS

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ACKNOWLEDGMENTS

I would like to express my thanks for all the assistance given to me by Dr. Richard Tinnell, my adviser; Dr. Donald Phillips, Chairman of the Technical Education Department; Dr. Cecil Dugger, also on my committee; and the other faculty members of the department who have answered my questions or have helped in one way or another.

I would also like to thank the members of Kappa Alpha Theta, Kappa Kappa Gamma, and Delta Zeta sororities for the countless hours they have spent, purely on their own free time. They have read endless pages of difficult and sometimes very uninteresting material since my blindness prevents me from reading it. Their services have been immeasureably valuable in completing this project.

I would also like to extend many thanks to Gordon Randall and Virginia Woodward of the Oklahoma Library for the Blind and Physically Handicapped for their assistance in finding materials relating to special recording equipment.

I also thank Gordon Randall for the encouragement he gave me while I was an employee at the Library for the Blind. While being allowed to work with and repair much of equipment in the library, I learned much valuable knowledge which helped, if not made possible, the writing of this thesis material. I would also like to thank the rest of the staff of the Library for the Blind for any assistance they gave.

Finally, the Oklahoma State University Library staff deserves many thanks for helping me find obscure materials and bibliographical notes.

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CHAPTER I

INTRODUCTION

Anybody who has been involved with technology, both mechanical and electrical, will probably agree that there has been a tremendous change in the types of electronic and mechanical devices which are available to the average person.

Up until the late 1950's and early 60's, the types of electrical devices found in most homes consisted of a few kitchen appliances, a washing machine and dryer, a television set, one or two radios, and a record player or two. The television was probably the most complex home electronic device for many years. The transistor radio was probably the first really unusual electronic device to be used in everyday life. While it worked on the same principle as the vacuum--tube sets, its mechanical construction and many of its circuit details were different enough to require repair technicians to learn some new skills.

This was just the beginning. Home tape recorders came along in the 50's but never reached truly wide use because of their reels which required a slight degree of pampering in order to work properly.

The 60's saw an explosion of new and improved devices for the home, school, and office. Home tape recorders started to appear with features which used to be found only on professional studio recorders.

Record players became hi-fi sets with stereo sound and impressive specifications.

In the middle 60's, a new dimension to home and educational sound systems came to be. This was the cassette tape cartridge and the recorders and players which would use it. In just a few years, home tape recording became a true reality. It was something which even persons who did not want to use complicated equipment could still do. It was, for all practical considerations, like taking pictures.

From the late 60's to the present, stores have displayed cassette tape recorders of every conceivable size, complexity, and price. According to Belt (1) there are 75 manufacturers making cassette equipment. Each of those companies may make several models spanning the range from very cheap to the best.

Like any mechanical device, the cassette tape recorder must have service. No machine, yet, has been made with an indefinite lifetime. It can be assumed that with the cassette industry, there must be also a cassette repair industry. It might also be assumed that the size of the market in cassette tape equipment would have a good deal to do with the size of the repair industry. It is not known just how many cassette recorders are in use now, but the number must surely be in the millions. Figures are released each year showing the number of tape recorders sold and the total number of home electrical appliances shipped in the United States. The figures (14) show that tape recorders only constituted 9.9 percent of the total electronic market in 1965. This was the year in which the cassette was first introduced (1). In 1970, the tape recorder had captured 28 percent of the electronic market.

The figures, taken from 10-year graphs in Merchandising Week (14) magazine, are shown below. The first column will be the year in question. The second column will be the total number of home electronic devices of all types shipped to the United States. The third column is the number of tape recorders shipped during that same year. And the last column is the percentage of the total made up of tape recorders. This last column has been figured to the nearest tenth of one percent and does not appear in Merchandising Week.

Year	Grand Total	Recorders	Percentage
1964	28,934,500	3,561,000	12.3
1965	34,800,000	3,445,000	9.9
1966	32,520,000	3,675,000	11.3
1967	33,718,900	4,563,000	13.5
1968	34,843,500	5,573,000	16.0
1969	33,571,000	6,929,000	20.6
1970	30,056,400	8,452,000	28.1
1971	32,729,400	8,747,000	26.7
1972	38,807,600	10,267,900	26.5
1973	73,154,800	12,000,000	16.4
1974	63,717,000	10,400,000	16.3

The data from Merchandising Week do not show what percentage of the tape recorders sold were cassette machines, but it is safe to assume that a large part are. It is not possible to find open-reel tape recorders in many places, however, cassette tape recorders and cassettes can be bought in almost any good-sized store selling general merchandise.

When these machines need repair, the owners can either take them to a dealer which can send the machine to some authorized repair point, or the owner may take it to somebody who repairs lots of different kinds of equipment, mainly radios and televisions.

The people who do this kind of repair must be familiar with many different types of equipment and must know as much as possible about their operation. One of the ways to learn is by obtaining written material on specifications from the factories or from companies who specialize in technical information. These pieces of literature run from articles about the general theory of operation of a piece of equipment to specification sheets on specific machines.

Of course, another way in which a person in the repair business can find out about a piece of equipment is by trial and error. This is the most time consuming and frustrating method. It may also result in making a slight problem into a major one. Unless the technician is lucky, neither he nor the customer will be satisfied with the final results and the technician will not really be any wiser as to what may have happened. To put it simply, the best course is to understand how the device works and find as much information about it as possible.

With certain types of equipment such as radios and televisions, an interested person has a wealth of information to study. Everything from books on general electronic theory to books specifically on radio and television repair are available at most electronics supply stores and at well-stocked libraries. The 1976 edition of <u>Books in Print</u> lists 26 separate titles under "Radio-Repairing." It lists 83 separate titles under "Television-Repairing."

When one tries, however, to find out about tape recorders and other sound equipment, the path is still there, but a little more winding. There are a number of books about tape recording and related fields, but there is only a small number about repairing cassette machines (17). In a large electronics store in Oklahoma City which sells both wholesale and retail, only one book could be found dealing with the general topic of cassette tape equipment (1). Another book on the shelf contained good schematics and mechanical diagrams for several models of cassette tape recorders, but no instructional theory for a repair technician who might be just starting to repair tape recorders.

The same shelves had a number of books for sale on radio and television servicing.

It appears from all of this discussion that a real need exists for material dealing more with the mechanical equipment found in the tape recording industry, particularly the cassette recorder field. This material needs to be slanted toward the technician who already knows about electronic equipment, but has not worked much with electromechanical equipment such as motors, drive systems, clutches, etc.

The purpose of this thesis is to survey the methods used to convey knowledge about the servicing of radios and televisions and to give an example of the kind of materials which might be used to train service technicians in the field of tape recorder repair.

While it is believed that much of the material presented to instruct service personnel could probably be gained over a long period of time and experience, it may be possible to speed the process on its way. It is believed that a cassette recorder repair technician, who learns the trade systematically will probably be more able to handle a larger variety of unusual situations than one who learns this aspect of the trade by chance.

This thesis, however, does not attempt to scientifically prove this hypothesis due to time limitations and the lack of already existing training materials or facilities.

It should also be made clear that there is believed to be no shortage of instructional material on the electronic aspects of sound equipment, including tape recorders. As will be shown in the succeeding chapter, what material which is available on tape recorder servicing generally spends more time and space on the electronics in the equipment rather than the mechanics.

From having actually observed persons who were competent with electronics work on mechanical equipment, it does appear that some instruction would probably make these people more efficient at their work.

One of the problems which occurs in situations in which electronics technicians make mechanical repairs is a reluctance to undertake the job in the first place. If several people are involved in the project, there may be much disagreement as to what kind of lubrication to use or whether some certain procedure might do more harm than good. Much of the discussion is based on past experience with similar mechanical systems. In other words, the methodical approaches and tests used in electronics are replaced by a more disorganized haphazard system. This is partly due to the fact that most mechanical problems are so obvious that detective work, as it might be called, is unnecessary. Some problems, however, may have their causes in mechanical components which do not immediately seem to effect the particular situation. In cassette machines, for example, many things can cause tape to tangle besides faulty cassette cartridges or weak takeup tension.

The repairer who has already been in the tape recorder repair business for several years will probably know most of this material and would benefit greatly from it. It is designed primarily to fill in some informational gaps for the person who has had some electronics training and would like to be competent in the repair of cassette tape machine.

Review of Literature

One assumption which was made in examining the literature on servicing equipment was that it would make little difference whether the material was about radios, televisions, or maybe even automobiles. This is because any information on repair of a mechanical or electronic piece of equipment involves some manual as well as mental dexterity. What exists, here, is almost a cross between an art and a science. There seems to be something similar in the discipline of knowing how to repair any kind of machine.

Since cassette tape recorders are electronic and mechanical devices, the literature closest to this topic was examined. Five books on radio and television servicing were chosen. The choices were made randomly from the shelf containing such material. The books contained copyright dates from 1948 to 1967.

Many books were excluded since they dealt only with electronic and or radio theory and had nothing or extremely little about actual practice. One thing which became instantly clear was the great number of books with similar titles, similar chapter titles, and similar content in the chapters. Another problem was the fact that the same author or authors were responsible for many different books. It seems, however, that the manner of presentation varies only in slight details from one book to another. If one takes into consideration the fact that technology has changed greatly in the last twenty years, it seems that the manner of presentation has not.

The approach is usually straight-forward. A particular topic is introduced, general information is given first, and actual examples of the particular device or principle are saved for last.

Having read other books dealing with repairing equipment of different types, it is safe to say that the format described above is seldom ever different.

One slight variation in the simple explanatory format was encountered in the book by Forest Belt, 1 - 2 - 3 - 4 Cassette Servicing. In this book, Belt tries to make the repair process as simple as possible by breaking it down into four basic steps. Basically, though, this approach does not really change the method of presentation. The material still appears in much the same manner in which it is displayed in other similar books.

All of the books examined seemed to be aimed at readers who already had a working knowledge of the very basics of radio and electronics but were not really experts in the field. This would seem to characterize a great number of technical people in many occupations. Books like the ones on radio and television servicing and cassette repair would probably be quite helpful. It must not be forgotten that many technicians may be very skilled in servicing a specific type of equipment, but not know anything about other equipment. What is even worse, some technicians may be so reluctant to attempt to service equipment which they feel is unfamiliar to them, that they may loose good opportunities in employment or experience. Books like the ones on radio and television servicing seem to be aimed at those technicians who want to expand their present knowledge and/or transfer it to other areas of their field.

One of the interesting things about the books examined here was the preponderance of books printed in the late 1940's and early 50's. Perhaps this is due to the fact that electronics, during that time, was changing, but not very rapidly. It was possible to write a book whose information would not be out of date for many years. Books on electronics which are written today are outdated in only four or five years. Of course, theory books are not perishable, but books on specific methods of circuit construction and design are, to some degree.

There is still a wealth of information available today. In fact, there is probably more now than ever before, but it is spread over a wider area. There does not seem to be a large number of informative books on general areas in electronics or electro-mechanical equipment.

Here is a description of what was found while examining one chapter from each of the five books on radio or television servicing.

In Radio Servicing: Theory and Practice, by Marcus (17), the chapter on servicing procedures was examined. Marcus does not get overly specific in naming different brands of radio and explaining how they work. He uses as much general information as possible and warns the potential service technician to be aware of differences which may be found and to try to figure out what the circuit does. Marcus talks about service procedures with the set off in one section, and then talks about service procedures with the set turned on. In each section, he gives the advantages, disadvantages, and proper use of the two procedure routines.

Buchsbaum (18), in his book, Television Servicing: Theory and Practice, uses specific examples of various brands of commercial television sets as examples of the circuits he is describing. The usual pattern is to explain a circuit from a theoretical point of view, then show a schematic diagram of the electronic circuit. Buchsbaum then explains how the circuit is tested and what the individual components do. The chapter used from this book was number ten and dealt with the television sound system. Buchsbaum also used the comparison technique to relate television sound to FM radio, with which it is similar.

A good example of a book in which a team of authors produced technical educational material is Elements of Radio Servicing by Marcus and Levy (19). This book, copyrighted in 1967, gave much general information. The test chapter in this book was the one dealing with automobile radio repair, Chapter 21. In this chapter, one schematic is used as an example of each of the three basic types of automobile radios, the old vibrator power supply type, the hybred tube-transistor type, and the transistor type of today. Many of the explanations, however, deal with different variations which may be found in different receivers. Generally, this presentation is more wide-ranged than specific and seems to cover the subject thoroughly. This chapter also had some quick hints for tests which could be done in the car itself (19).

In Television and FM Receiver Servicing, Milton S. Kiver (10) uses numerous examples of commercial FM radios to demonstrate the different kinds of modulation detectors and tuner sections which were common in that day. In Chapter 13, Kiver uses basic theory to lay the groundwork for each explanation of the commercial circuit in question.

In Television Receiver Servicing, also by Kiver (21), Chapter 7 was read. This chapter dealt with the TV picture tube. The same techniques of theory and descriptions of practical picture tubes were used. Since picture tubes of the same basic type are supposed to be interchangeable, the descriptions deal with type of CRT's or picture tubes rather than the mentioning of specific manufacturers as is done in the more specific circuit designs found in various makes of radio or television sets. There was also a description of the nomenclature used in classifying the different types of black-and-white picture tubes. Due to the 1959 copyright date, it is understandable that color television was not given as much space as it probably would have been in a book of today.

Again, it can safely be said that most explanatory books such as the ones on radio and television servicing are presented in much the same style. General information is followed by more specific information. Specific examples are used more frequently in some books than others, but this is the only real difference between books.

The quality of writing, as far as clarity is concerned, seemed to be reasonably good with more attention given to practical information than to abstract theory or mathematics.

CHAPTER II

METHODOLOGY

The idea, here, was to create some instructional material which could fill some of the gaps previously mentioned.

It had to be determined, first, who would be a good group at which to aim this material. It was decided that the group which could use it best would probably be radio and television repair technicians, especially those who were just starting work in their field.

It was decided to use the informational approach mixed with examples of actual equipment. This method was chosen because it seems to be the best and is most widely used.

Although examples are used, brand names and model numbers have not been used because the purpose is to inform the reader about operating principles of different equipment rather than specific service information. Many times when a circuit or mechanism proves satisfactory or results in lower production costs it is eventually adopted by many different manufacturers.

It is also true that anything as complex as a tape recorder contains many subassemblies and those subassemblies may be made by as many manufacturers as there are subassemblies.

The theory behind this material was that a technician could do a better job of servicing all brands and types of cassette machines if that person had a good understanding of operating theory.

An informal conversational tone of presentation was chosen because it is a comfortable style to read and the total purpose is to inform. It was believed that some, if not many, of the technicians would be intimidated by a very formal approach. Since the material was designed to give service and theory information and not as a basis for engineering design, abstract math and theory was kept to an absolute minimum.

Since the best form of instructional hardware is the actual equipment, the material was designed with the belief that a training program in cassette repair could be conducted in a place where the students could have access to cassette machines. These machines, in various stages of disassembly, could probably be obtained in any fairly good-sized town from interested citizens, repair shops, and anywhere else which seems possible. A workshop-like atmosphere could probably be created quite easily with lots of different makes and models of machines. The bulk of these machines would probably be in the low end of the price range since these machines would be most likely cast off when broken.

At the end of each chapter, where practical, suggestions are made pertaining to experiments which could be done to demonstrate certain ideas or disassemblies which could be made to examine certain parts or mechanisms. A good supply of junked cassette machines and even broken cassette cartridges would be quite valuable for these exercises.

Since the primary stress is on mechanical systems, this material should not be used with students who have not already had some electronics training. Electronic servicing has not been dealt with in any great detail because there are so many good books already existing on the subject. The only real mention of electronics is of those things which seem to be omitted from most other textbooks.

What now follows is an example of the kind of material which seems to be needed now to better train repair technicians.

CHAPTER III

RESULTS

Unit 1

The purpose of this book is to provide the radio and television repair technician or a student learning the electronic repair business the skills and information needed to learn the tape recorder repair business.

It is aimed primarily at those people who have had some electronics training but have not done any work in the tape recorder repair area.

Many of the physical and mental skills which make good electronic repair technicians are also necessary in the repair of cassette recorders.

This book is designed to be used in a setting which should allow the students to perform actual repairs and examinations of equipment.

Since many good books already exist in the electronics field, electrical theory is kept to a minimum. The only areas dealt with in detail are those in which literature is difficult to find.

The idea, here, is to make the repair technicians aware of the different basic types of cassette machines which exist so that servicing can be as systematic and logical as possible. Knowing as much as possible about the operating principles of a given cassette recorder will be, next to a good set of tools, one of the most valuable service aids.

Unit 2

Just what is a cassette recorder? Today's cassette recorder is not actually all that different in operation from tape recorders of the last 30 years. It is simply the latest in a long series of improvements. Early sound tape recorders used a quarter-inch wide strip of paper covered with iron oxyde for a tape. This tape was stored on one reel and passed through the tape recorder to another empty or takeup reel. The operator had to thread the tape himself from the supply reel to the takeup reel.

The tape and the recorders improved greatly between the early days after World War II and the present day, but the recorders and operating procedures stayed basically the same. In the early 60's a new tape system came on the market. This was the eight-track endless loop cartridge. In this system, tape of the same kind used in open reel recorders was wound on a central spool. The spool was made so that tape could be pulled away at the same time it was being wound onto the spool. The ends were spliced together and the resulting package could be plugged into a machine designed to handle it. This system was meant mainly for use in automobiles. Stereo music could be recorded on the tape and this tape would keep running constantly over and over. The driver of the car could remove or insert the cartridge with one hand and no threading was needed.

The eight-track cartridge is still in wide use today. It is not, however, used for very many other uses than automobile music. Home music systems use the eight-track cartridges, but their biggest acceptance by the public has been in the noisy, somewhat less demanding environment of the car.

Another reason why the tape cartridge system described above is used basically for music only is that the tape can only be run in one direction. For that reason and the fact that the tape has no definite end point, it is difficult to find a specific spot on the tape.

This brings us to the cassette. The name actually means little case just like the word cigarette means little cigar.

It was the brain child of the Phillips Corporation of Holland. The company wanted to make a tape recording and playback system which could be simple, reliable, and standardized. Originally, Phillips wanted to make a tape system which would do for sound recording what the pocket camera did for photography. The designers wanted a low cost, portable machine whose recordings could be played on any other Phillips machine. The first machines were sold by Norelco which is North American Phillips Incorporated.

Other companies began making cassette machines but under the patent licensing agreements their machines had to be compatible with the Phillips system.

The Phillips tape system simply incorporated much of the open-reel system into a smaller, easier to use style or format. The little case or cassette as it is called holds both the supply and takeup reels. These are actually not even reels in the true sense of the word but small round rings. The inside of the cassette forms the rest of what would have been the sides of the reels. The inside of the cassette, in fact, must be very smooth since it is still while the hubs of tape turn. The actual construction of cassettes will be discussed in more detail because this, in itself, can be the source of problems which can, at times, appear to be caused by the cassette tape recorder but are actually a result of the cassette cartridge.

Unit 3

It will probably be easier to understand the different parts of a cassette recorder if we first study a whole working machine. The best kind for this purpose is any low to moderate priced machine which has only the basic controls and does not have an automatic shutoff which would make some of the things we are about to do a little more difficult. The cassette compartment or well also needs to be easily explored. Some machines are better suited for this than others.

For simplicity sake, the place where the tape heads are in the cassette well will be called the front. In most recorders, this area will be toward the user.

Let us now look into the cassette well of a recorder. In the rear of the well, on the lefthand side, is a small pointed object. This is a safety lock which prevents someone from accidently erasing cassette tapes whose rear tabs have been punched out for this purpose. Coming now toward the front, you should see the two spindles which fit through the cassette and turn the tiny reels inside the cassette cartridge. In the front of the cassette well, there are two tape heads which, when the machine is not in play or record may be partly hidden. In the far right front, to the right of the heads is a short metal rod called the capstand. A rubber roller sits close to the capstand. It is the pinch roller. You will find all of these things in every cassette recorder you will ever see. Sometimes you will see additional items on some machines such as automatic shutoff levers and other special controls, but these are the basics.

Now, let's find out what all these things do.

In order to see how the safety device which keeps certain cassettes from being re-recorded works, take a standard cassette which can be used to record with. Look at the rear of the cartridge. On the back edge are two small squares, one on each end. These squares are cut into the plastic so as to make them removable. A sharp object can punch them out. When you put a cassette into the well of your machine, you will notice that the safety lever just fits into one of the little squares. If the squares are not punched, the lever will be pushed away. This will make the record mechanism ready for use. If the little square opening has been punched, the lever will not be moved when a cassette is in place. The record mechanism is thus disabled. This means that you cannot put a cassette recorder into the record operation when there is no cassette in place. In many machines, this safety lever simply provides an obstruction which keeps the user from pushing the record button. Pushing the lever away from its natural position removes the block and the machine can record.

Since there is only one safety lever and two punchout tabs, it is possible to make one side of the cassette record proof while keeping the other side reusable.

Next we come to spindles. Their most obvious purpose is to wind the tape from one of the reels in the cassette to the other.

Put your machine in rewind without a cassette. The left spindle should whirl clockwise. Change to fast forward. The left spindle will stop and the right one should spin counterclockwise. Still leaving the cassette out of the recorder, put the machine in play. The righthand spindle will start turning again. It may spin as fast as it did in fast forward or it may be slightly slower. This would depend on the make of machine being used and the way the mechanical system is built. Nevertheless, the right spindle should turn in the same direction it turned in fast forward. You also notice something else has happened. The tape heads have come forward to meet the cassette which would normally be there, and the pinch roller has now met the capstand.

Imagine what the tape would be doing when in place. Remember that the full reel would be on the left. This is the spindle which is not moving. If you grasp it with your fingers, you can turn it freely. Think of the tape being pulled off the supply reel on the left and being pulled across the two heads. The tape goes between the capstand and pinch roller which do the pulling. It is like the old-fashioned wringer-type washing machines which used to pull clothing and an occasional hand through them.

The tape is being pulled from left to right. On the righthand side of the capstand and pinch roller, the tape could just pile up. In a properly working machine, this does not happen. A little experiment will show how the takeup system works.

Reach into the cassette well while the machine is in play and take hold of the right spindle. It should stop easily even though the rest of the machine will continue to run. Now gradually let go. The spindle will start to turn slowly in your hand and then pick up speed as you release your hold. Notice that the pressure of the spindle trying to turn is steady and smooth. In the type of machine we are describing, the takeup spindle gets its turning motion during the play function from the motor which drives the capstand. The spindle, however, is connected by means of a clutch which is purposely made to slip.

This slip clutch lets some of the force from the motor turn the spindle but not all of it. If all of the force came through, the whole machine would stop when the takeup spindle was slowed or stopped. When a cassette is in place, this takeup spindle simply puts a gentle steady twisting pressure, called tork, on the takeup reel. As the capstand feeds tape, the reel turns and picks it up.

You will later find that some more costly cassette machines use a completely different method of providing tork for the takeup spindle, however, the results are exactly the same.

Unit 4

Before going further into the insides of a cassette tape recorder, let us look a little at the cassette tapes themselves. These tape cartridges can, and many times are the source of problems which may seem to be the recorder's fault. The best way to understand what can happen is to take some cassettes apart. To get into most cassettes, all one needs is a sharp knife and something to pry with like a screw-driver blade. It should be understood, here, that opening the cassette cartridge in most cases breaks some of the plastic parts which guide the tape so it is a good idea to use cassettes which have already failed for some other reason. This way, nothing is really lost.

Take the knife and start cutting the plastic near the front of the cartridge. This is the area with the windows which expose the tape. But using the knife and screwdriver, split the seam which joins the top and bottom halves together. When you think you just about have the top split away, hold the cassette over a table and be especially careful so that the top will not fly off suddenly and cause all of the small parts inside the cassette to spill before you have a chance to look at them.

Let us now assume that this controlled distruction has been successful and the top half of the cassette has broken free. It can be set aside. All of the parts will most likely be in the bottom half. They will all spill out, however, if you tip this half upright. The only thing holding the parts in most cassettes is the two halves placed together.

What you will see in this bottom half may vary some depending upon the manufacturer of the cassette. What seems to be most common in low-price cassettes is first a layer of thin plastic slightly thicker than a candy wrapper. This layer may stick to the top when you remove it so look there if you don't see it. Some cassettes don't have this layer at all. The layer may be frosted on the side which touches the tape. This is to keep the little reels of tape from sticking or jamming as much as possible.

When the plastic cushion is lifted out, you can see the two little reels of tape. You may notice that these reels have no sides. The tape is simply wound tightly around a little plastic ring or hub. It may be possible to tell how this particular cassette came to its fate. The tape may be broken inside the cartridge. If the cassette has been wound all the way to one end or the other, you will notice that the very beginning of the tape is much thicker and heavier than the actual tape which is on the rest of the reel.

This thicker tape is called the leader. It is found at each end of the tape. It may or may not be clear, but whatever color it is, it does not have the iron oxyde coating on it and cannot record sound.

After a short distance, the leader is spliced onto the recording tape. Here is where a problem sometimes occurs. You may see a cassette in which the leader has pulled away from the tape. You may see a cassette in which the leader is still attached to the tape, but it has pulled out of the little slot in the plastic hub. Sometimes, these little slots have a tiny plastic bar which is forced into the slot along with the tape. This bar may have fallen out or may fit loosely enough in this particular cassette to have allowed the leader to pull out. The leader is there in the first place to handle the hard snap which happens when the tape comes to the end especially during fast forward and rewind. The thin magnetic tape would probably not stand more than a few such snaps before it stretched or broke.

If the tape is still in place, notice how it travels through the cartridge. You may see it leave the lefthand hub and travel through a guide and around a little roller which turns freely on a tiny spindle. The tape then turns a corner and leads across the front of the cassette. One of the most important parts of the cassette is right in the middle window. It is that little soft pad behind the tape. This is called the pressure pad.

The pressure pad pushes the tape toward the recording head and keeps it in contact all the time during recording and playback. The pad must keep the tape at an even pressure against the head and it must also push the tape flat against the head. You may notice that the pad in your cassette has a little metal U-shaped holder behind it which keeps it in place. The pressure pad usually has a thin metal strap-like spring coming from either end of it. This spring causes the pad to bulge outward so as to meet the head. This particular cassette which is being examined at this time may have been discarded because the pad collapsed or broke loose. Some cassettes do not have a holder for the pad but rely on moldings in the plastic case to hold the pad. If you pick up a cassette and look at the pad, shake it or tap on it, and the pad is slightly shifted in position or has moved to one side of the window or the other, you can be almost sure that this cassette will cause trouble sometime. The recordings it makes will sometimes be muffled or may even not be there at all. When trouble-shooting a cassette tape recorder, always make sure that the cassette cartridge itself is working properly.

Going back to the inside of the cartridge once more, another possibility for trouble exists which is harder to spot but which takes a tremendous toll of cheap cartridges. This has to do with the fact that the tape reels have no sides on them and the tape can rub against the sides of the cassette itself.

Normally, the tape slides smoothly against the inside plastic cushions or the polished plastic sides or covers of the cassette. Sometimes these plastic sides become warped with age or exposure to extremely hot or cold temperatures. When this happens, the inside of the cassette may squeeze the tape too tight or become too loose. Some of the tape may slip downward while it is being wound. As more tape is wound, it will follow that which is already crookedly wound. Even though it may have only barely slipped a little, it may cause enough of a ripple in the surface of the winding tape to rub against the top or bottom of the cassette. As more tape rubs against the housing of the cartridge, it will eventually reach a point where it stops altogether.

Now, let us fit what we know together. Imagine a crookedly-wound cassette in the machine. The tape is being pulled by the capstand and pinch roller assembly. If the crooked part is on the supply or left side of the capstand, it may simply keep the capstand and pinch roller from pulling tape. This will make the machine slow or stop. If, however, the problem is on the takeup side of the capstand, another problem results. The gentle tork on the right spindle is designed to be just strong enough to pick up the excess tape and wind it just hard enough to keep it from slipping away. If it winds crookedly, it may bind against the cassette covers and stop the spindle from turning. The capstand will keep pulling tape from the supply reel, but it will have nowhere to go but to spill out of the cassette into the machine.

The cassette machine may have been adjusted perfectly when this happened and the fault lies totally with the cassette itself. It may also be true that the takeup tork has become less than it should be on this particular machine. This is one of those areas where experience at cassette repairing will help you decide when to test the tork or simply tell your customer to buy better quality cassettes. A general rule would be to try to determine how often the machine tangled the tape. If it does it almost all the time, the problem is probably with the machine. If it does it only with a certain brand of cassette, and then only once or twice out of many successful operations, the problem is probably with the cassette cartridge. This is especially true if the cartridge has been played 20 to 30 times.

The discussion has basically been about low-cost cassettes. In general cassette recorder servicing, you will see these cassette cartridges more often than the expensive kind--three dollars and up. Some of the expensive cassettes have small screws holding the shell together and replaceable parts. Most, however, are basically unrepairable although the life of a cartridge which has failed once can be extended with minor surgery long enough for a person to save some cherished recording by re-recording it onto another tape.

Unit 5

Before somebody really becomes good at cassette recorder servicing, this person should have some slight idea of what happens in the electro-magnetic recording and playback process.

It can be safely said that electricity and magnetism are closely related. Over a century ago, a scientist found that moving a coil of wire near a magnet made a faint electric current. It was also found that running electricity through a coil of wire produced a magnet. Between that early time and now, hundreds of thousands of different uses for this principle have been discovered. These uses of electricity and magnetism range from giant generators and motors to the tiny delicate moving parts in magnetic phonograph pickups.

When a magnet is made by running electric current through a wire, we say it is an electro-magnet. This magnet has a north and south pole just like a permanent magnet or, for that matter, the Earth itself. If the current is reversed in the electro-magnet, the poles will also reverse. This means that an electro-magnet never has a permanent north or south pole.

A permanent magnet can be placed next to an electro-magnet so that the two will pull tightly together when electricity flows one way and push or repel when the current is reversed. Here is a small experiment to demonstrate this.

A modern speaker such as is found in radios and tape recorders has a large magnet. This is the round hub or cylinder-shaped object at the rear of a speaker. If you look into the paper cone, you will see a circle at the small end. This is the outline of the coil which is just large enough to fit over the body of the magnet. Take a single flashlight cell and hook the plus or positive terminal to one speaker connection and the negative terminal to the other connection. You will hear loud static and you should see the speaker cone jump slightly outward or pull slightly inward. Take note of what it does. When you reverse the wires, the cone will do the opposite of whatever it first did.

To demonstrate the generation of electricity, you can connect a pair of headphones directly to the speaker connections. Now tap on the speaker. You will hear a faint sound in the headphones. The room should be quiet for this, because the electric current is not strong and the sound will be weak. This is basically how the first telephones worked. It should be stated here that this is how the magnetic or dynamic microphones found on many tape recorders work. Speakers, themselves, are sometimes used as microphones.

Now let us see how all this applies to tape recording. If you take a piece of magnetic tape and hold it near a magnet, the magnet will grab it like it would a piece of iron. This is because the coating on the back of the tape is made of material which can be attracted by a magnet. The material on the tape, however, is not only attracted by a magnet, it becomes magnetic itself. It simply keeps some of the magnetism it picks up from a magnetic source. If you hold a piece of magnetic tape near a piece of iron, it will not be pulled toward it, though, because the magnetism is very small. It is there just the same.

The record-play head in a cassette machine is a type of electromagnet. It has no magnetism normally, but becomes magnetic when fed by an electric current. The magnetic tape heads used in cassette and open-reel machines are coils of fine wire wound around almost complete rings of iron. These almost complete rings are like horseshoe magnets whose ends almost, but not quite, touch. This concentrates or focuses all the magnetic force in the coil in one tiny spot. The closer the ends are to each other, the finer the spot. It is possible to imagine this gap as a hairline split in the middle of the head. It runs at right angles to the tape. In modern tape heads such as are used in cassette machines, this gap is so small it cannot be seen but it has to be there in order for the head to send and receive magnetism.

As was said earlier, the magnetic coating on the tape can hold any magnetism which it is exposed to up to a certain amount. The electric currents which carry voice and music to the recording head of a tape recorder, constantly change in strength and direction or polarity. The tape which running past the head moves fast enough that these changes can each be stored in the magnetic film on the tape. The tape becomes like a bunch of tiny magnets of different strength and polarity, each one a sort of photograph in magnetism of how the magnetism of the tape head was at that particular instant.

When the tape is played, the whole process is reversed. The patches of magnetism on the tape coating move past the gap in the head.

Each one produces an electric current of varying voltage and polarity reflecting the voltage and polarity when the tape was recorded. These voltages are fed through the amplifier and to the speaker where they recreate the voices and music as they were originally recorded.

This is a short explanation of how magnetic recording works. There is somewhat more to it than first meets the eye. First, even brand new tape may have some magnetism on it. It will not be voice or music, but random spots which will make funny noises in the speaker of the tape recorder.

It also means that the recordings might have these noises on them because the new magnetic signals will simply go onto the tape along with the old ones. This is why cassette tape recorders have two heads. The one on the left as you look into the cassette well is the erase head. In some low-cost machines, this head is a DC or direct current electro-magnet which magnetizes all the tape the same way. The recording signal, then adds to this magnetism or subtracts from it. This works fairly well, but roaring noises can sometimes still be heard. Better quality recorders use an alternating current which changes direction at a speed so fast that it makes no sound of its own on the tape. This constant changing current and magnetic polarity tends to demagnetize all of the tape coating material leaving it magnetically clean for the new signal. The new signal is mixed with some of this high speed or high frequency alternating current to make sure that the magnetic record of the sounds being put on the tape properly matches the actual signal. This may seem a little confusing at first. It is necessary to do it this way, because the magnet material, even when magnetically clean, will not always retain or hold the signal in the same strength it should to cause the playback to sound like the original. This process of mixing a steady signal with the incoming sound material being recorded is called biasing. The high-frequency alternating current which does the erasing and biasing functions is called the bias current.

While the electronic engineers who design cassette tape recorders worry about how to design the bias circuits, the person who repairs cassette machines will need to know, by looking at the schematic diagram of that particular machine, what kind of bias system it uses. This will not effect the playing of tapes, but it will make the difference between knowing a possible cause of trouble in the recording section and simply being confused by what may seem like unrelated problems.

There is no sure way to tell, just by looking at a cassette machine from the outside whether it has a DC magnet or AC biasing system. As a rule, the more expensive machines have AC bias whether they are portable or not. Don't confuse whether the bias is AC or DC with the fact that the recorder may get its power from the AC wall outlet or DC flashlight batteries.

Another little problem with present-day magnetic recording is that, even with proper biasing and erasing, the recorded signals do not come off the tape exactly the same way they went on. This has to do with the fact that a fast moving magnet generates more electricity than a slow moving one. On tape, low-pitched sounds like a bass fiddle or a man's voice cause large areas of magnetism to appear on the tape. These large areas of magnetism are solid and are seen by the playback head as a slow-moving magnet. It is somewhat like watching a string of vehicles going at the same speed down a highway. A motorcyle looks like it is going faster because it passes quickly while a large truck takes several times as long to get out of the line of sight.

High-pitched sounds like a flute, for example, would make a string of small magnets appear on the tape. These would come and go much faster than the magnetic spots produced by the low-pitched sounds.

What this all means is that the high-pitched sounds naturally make a higher electrical voltage in the tape head. A higher voltage means a louder sound. Originally, the man's voice and the flute might have been recorded at the same electrical level. In other words, if just left to nature, all of the high sounds recorded on tape would be many times louder than the low sounds. It would not sound right to the ear at all. Fortunately, it is possible to predict how much increase in sound level there would be for any given pitch of sound. Tape recorder manufacturers design the amplifiers with circuits which make them less sensitive at higher pitches. The lessening of sensitivity is exactly equal to the increasing output from the head. This process is simply called "equalization." Since the kind just described affects the playing of tapes, it is actually called playback equalization. There is also some modification of the recording signal to improve the sound even more. This is called record equalization. It is all done automatically and in many cassette machines, there is no adjustment to worry about.

In repairing cassette machines, it may be kept in the back of one's mind that the equalization which takes place is fairly standard from one cassette recorder to another, but may be just enough different to make tapes recorded on one machine sound a tiny bit different when played on another. Equalization circuits are fairly simple in their actual construction and should be considered almost last when trying to pinpoint the cause of a problem. As with the biasing circuits, there is no substitute for knowing the particular machine in question and what kind of tape it is to be used with.

The brings up one final topic in the general subject of magnetic recording. Tape is not the same the world over. While it is true that cassette cartridges can be played on any cassette machine, some cartridges are designed for different purposes than others. In the last few years, tape manufacturers have tried to make their tapes able to record music with better and better quality. Iron oxyde, the coating on tape for years, was found to be not as good as some other metal oxydes such as chromium dioxyde. Unfortunately, the tape machines designed for iron oxyde tape don't record very well on chromium dioxyde tape and vice versa. The machines used with chromium tape have higher bias currents and slightly different equalization. If a person records the wrong kind of tape on the wrong machine, the result will be a recording alright, but it may sound strange. When servicing cassette machines, one must be aware of this possibility and make sure that the customer knows about this difference.

It is a good idea to read the high fidelity adds in stereo magazines in order to keep up with this area. New kinds of tapes are coming on the market all the time and some of them will work under a wide variety of operating conditions and some just won't.

Unit 6

Here, we will look at the mechanics of a cassette tape recorder. Even though there are from 75 to 100 different companies making cassette machines, there are only a few basic designs (1).

The most common design in low-cost portable machines if the single-motor mechanism. This type is also found in a few non-portable cassette machines and in many open-reel tape machines.

In the single-motor tape drive system, one motor does all the tape moving whether it be rewind, fast forward, or play and record. These last two functions are mechanically identical from the tape moving point of view.

If you have ever seen any moving gears such as in a transmission of an automobile or any other kind of gear box, you can see how a motor turning in one direction can be made to turn something else faster, slower, or in the reverse direction by simply adding, removing or changing the size of the gears.

Gears aren't used very much in tape recorders because they make noises and may not turn perfectly smoothly. Even nylon gears can growl or whine when they turn fast enough. Instead of gears, friction drive mechanisms are used.

One of the simplest frictions systems can be found in any small record player. A small phonograph might be a good thing to dismantle to get used to handling the kind of hardware you will find in cassette machines. First remove the turntable by taking a screwdriver and slipping off the C washer. This is the large metal washer which you will find holding the turntable onto the record spindle.

Some record players may have a stiff piece of wire bent into the shape of a hairpin. This is called a hairpin clip and works the same way as a C washer. Be careful when removing C washers that you slide them straight out so they will not be bent. Put the washer or hairpin clip somewhere safe such as a cup or dish. One of the cardinal rules for doing a good efficient job of servicing mechanical devices is save everything, at least as far as washers, nuts, bolts, and other fittings. Manufacturers are notorious for using specially made fittings which may look similar to others, but will only fit that particular model of machine or machines made by that particular manufacturer.

After the C washer has been removed from the turntable, lift it off. If it is an old record player, don't be surprised if it does not come off easily. It may be necessary to stick a screwdriver under the edge of the turntable and pry gently while striking the spindle with the handle of another screwdriver. When the turntable is away, you should see a mechanism consisting of a round wheel, usually about the size of a small can lid. This wheel will have a rubber tire on it which is usually smooth. The mechanism will also probably have a lever which leads outward to the speed changing control on the machine. Next to the rubber wheel, there will be a motor shaft sticking up through the board on which all of this is mounted. The shaft may be in four sizes with the largest diameter on bottom. When you move the speed lever, notice that the rubber wheel moves up and down and contacts the different sizes on the shaft. When the wheel is on bottom, touching the largest size on the shaft, the machine is in the 78 RPM speed. If the machine was a four-speed variety, the smallest diameter will be the 16 2/3 position.

If the phonograph is capable of operating and there are no exposed power wires in the area where the turntable was, turn on the machine and push the rubber wheel against the motor. In normal operation, the turntable would provide the back support for the wheel. You will see that the motor turns in the opposite direction from the wheel. Think for a second and you will see that the turntable turns in the same direction as the motor. This wheel, between turntable and motor, is called an idler wheel because it is not directly connected to any mechanism. It just spins around on a little shaft and brings the motor speed down to something between the very fast motor speed and the slow turntable speed.

You will probably also notice a spring which pulls the idler wheel in the right direction for proper operation. It usually pulls at an angle to keep the wheel snugly between motor shaft and turntable.

While moving the speed lever, you may notice that the sliding parts of the speed change mechanism are notched so that the rubber wheel is pushed out of the way between steps or speeds. This is to keep the motor shaft from chipping away at the edge of the wheel when, for example, the speed is changed from a slow one to a faster one. Notice everything that the mechanism does. While it is different from the mechanisms in a cassette recorder, it is a good place to start learning about the kind of mechanisms found in a cassette machine. This is because it is simple, straightforward, and easy to figure out.

The moving parts of the speed changing mechanism are, more likely than not, held on by C washers. Practice putting them on and taking them off a few times. These washers are usually a little larger than the ones you will find in a lot of cassette machines.

Now we are ready to tackle the inside of a cassette machine. The machine for use in this chapter can be any low-cost portable, hopefully one with plenty of room so as to allow for easy examination of the parts.

Remove the screws from the back and take the top plate off if possible. Expose as much of the mechanism as you can and still be able to operate the buttons or switches. Some machines may have their mechanisms obscured by the printed circuit board for the amplifier. If the machine is being salvaged, the circuit board can simply be removed, however it most easily will come out. In most machines, however, you should be able to see much of the mechanics without completely dismanteling the machine.

One of the most obvious parts will probably be the large flywheel attached to the capstand. This wheel may have a strut across the back of it to hold it in place or it may be supported by some of the framework holding other parts of the drive system together. In any case, locate this wheel. It most machines, it is solid metal, about five or six centimeters across, (2 or 3 inches), and has a rubber belt around it.

This flywheel is usually rather heavy for its size. This is because it must turn at an exact speed. The belt around the flywheel may look like a slightly thicker and heavier version of the rubber band seen around newspapers. This belt is the other main part found in friction drive systems. Most cassette recorders do not use the friction drive wheels found in small phonographs, although this could be done. They, instead, use a rubber belt. Only one tape drive system for cassettes uses a friction-drive system and that unit is not one of the low-cost portables (1).

Follow the belt from the capstand and see where else it goes. It may just go straight to a small pulley which is the motor drive shaft. In other machines, it will still go to the motor, but there may be an idler or two pressed against the belt somewhere between fly-wheel and motor. These idlers can serve different purposes depending upon the manufacturer of the machine. Some manufacturers use an idler pulley to get power for the takeup spindle to turn during play-back or record. The idler, in a situation like this, would probably be mounted so that its outside ring pressed firmly against the flywheel belt. The idler pulley is actually more than just a pulley. It is also a speical slip clutch. The central shaft of the pulley is actually a separate part. Close inspection will reveal that the outer rim of the pulley has a layer of felt inside it. The mounting shaft comes up through the middle and has a disc on it.

The disc covers the center of the idler like the hubcap of a tire. There may also be a spring holding the two items together. This spring is not bound to either part except by its own tension and can turn free-ly. Its purpose is to press the disc against the felt. All of this simply allows the idler to get power from the belt and transfer it to the takeup spindle. If there were no slip clutch, the idler would drag the motor to a stop or the belt might break. The idea is to get just enough tork or twist on the takeup spindle that tape will be picked up after it leaves the capstand.

Some manufacturers use an idler to get power for the rewind and fast forward (1). An idler like this would be a simple pulley which would not have a slip clutch. Its shaft would go through the chassis of the machine to the top side where it would have two possible endings. It might have a belt or two on it depending on the manufacturer or it might have a rubber friction wheel on it. When, for example, the machine is placed in fast forward, this rubber friction wheel might be contacted by another wheel which is also in contact with the takeup spindle. The same sort of thing would happen in rewind only another additional idler might be brought into play because the rewind spindle must turn backwards in relation to the takeup spindle. If the end of the idler shaft terminates in belts, the belts will themselves end in wheels which are pressed against the takeup or rewind spindles as desired.

While all of this sounds terribly confusing, remember that what is being described here is a composite of the sorts of things found in most portable, single-motor cassette tape recorders.

One specific recorder, for example, contains one drive belt. The takeup tension is achieved by an idler pulley with a felt slip clutch. The shaft of this slip clutch sticks through the chassis. On the top, or cassette side, this shaft appears as a little metal driveshaft. When the machine is in play or record, this drive shaft is pressed against a rubber drive wheel which is actually the outer rim of the platform that holds the takeup spindle. In other words, the takeup spindle and rubber drive wheel are one assembly. When the machine is in any other function besides play or record, the idler and slip clutch assembly are moved a fraction of a centimeter away. This is just enough to keep the drive shaft from contacting the rim of the spindle. Rewind and fast forward get their power from another idler. This idler also extends through the chassis. On the top side, actually under the plastic bottom of the cassette well, is a series of friction drive wheels. These wheels are pusehd into and out of action by the metal levers attached to the rewind and fast forward push keys. For fast forward, the drive shaft of this second idler is moved against the rubber rim of the takeup spindle. Since there is no slip clutch, the tape winds very fast. As in all cassette recorders, the capstand actually turns just as it does during play and record, but it does nothing to the speed of the tape because the pinch roller is back and is not engaged. For rewind, a secondary friction drive wheel is pressed against the idler shaft. This second wheel is the same size as the rubber rim on the rewind spindle. It is inserted between the idler shaft and the rewind spindle. This second wheel is an idler also.

Remember that the idler which drives fast forward and rewind always turns the same direction. The reverse of direction for rewind is accomplished by that second idler wheel.

When repairing a cassette machine, it is important to know the mechanical relationship between all of the parts. Push the buttons slowly and watch what happens. There are a few actions which are common to all of the push buttons except the stop button. Cassette recorders have brakes to stop the spindles after the machine is shut off. These brakes are usually mounted on a bar with one brake going to each spindle (1). If any of the buttons are pressed except stop or possibly record, the brake bar is pushed out of the way so the brakes no longer touch the spindle rims. Also, somewhere around the brake assembly is a switch for the electricity. This switch is usually a simple affair made of two metal fingers held together by some plastic insulator. The free ends of the metal fingers are slightly apart. The switch may be mounted on the chassis in a fixed location. When the brakes release, the brake bar may hit one of these metal fingers and push it into the other. This completes the electric circuit from the batteries or power adapter to the motor and amplifier.

The stop button simply removes any latches which have been holding any of the buttons in.

Finally, in each brand of cassette machine you see, there will be differences, but the end result will be much the same from machine to machine.

To summarize this rather long unit, it can be said that cassette tape mechanisms for single-motor machines are different from maker to maker, but their similarities far outweigh their differences. Before actually dismanteling a cassette machine, it may be good to start with a simple mechanism such as the mechanism of a small record player. While the mechanism will not be the same, it will give you a sense of familiarity, nonetheless, with the more complex group of mechanisms in a portable cassette machine. If possible, look at several different makes of machines to see their similarities and differences. Try to imagine what could go wrong if different parts of the mechanism were worn. While it is fairly obvious what can happen when major parts are broken, worn drive pulleys and slip clutches can cause some rather interesting puzzles.

Unit 7

It is time to look at some of the problems found in single-motor cassette tape recorders. All of the belts, friction drive wheels and slip clutches described in the last chapter are a fertile field for trouble. While they can work properly for years, they all have a lifetime after which they are useless.

Rubber friction wheels are like the tires on a car. After so many revolutions, they become worn and start to slip. There can be two reasons for the death of a rubber wheel; one is from use and the other is from age. Heat and dirt can speed the aging process, but rubber wheels will gradually loose their traction after many years.

It takes some practice to tell when a rubber drive wheel has come to its end. Several different things can be used to judge the condition of the wheel. Most new rubber wheels have a slightly frosted finish to them to make them push against whatever they are driving with a nice even firm pressure. When the wheel gets old, the surface becomes shiny. The wheel is said to be glazed. This glazing has the effect of polishing the surface and making it slippery.

If the rubber becomes very old, usually after four or five years, it may become dead or dry. In this case, the edge of a rubber wheel will have a grainy feel to it. The surface of the rubber will be hard and woodlike. One good way to judge the quality of a rubber wheel is to run the back of a fingernail over it. If it is good, the fingernail will meet resistance. It it is glazed or dry, the fingernail will slide over the surface without much resistance. Oil will ruin the capability of a rubber wheel to drive properly also.

Alcohol, oil, and heat will hasten the aging process for rubber wheels. A combination of some or all of these things will surely ruin a rubber wheel which might have lasted for many years under proper conditions.

Sometimes, methods can work for bringing slightly worn rubber wheels back to life. These are temporary at best. For example, it is possible to take an emery file and go around the edge of a rubber drive wheel to deglaze it. This will tend to make the surface frosted again. If it is not done carefully, it will also make the surface uneven. This will merely exchange one problem for another. There are cleaning and deglazing compounds available which claim to make rubber drive systems like new. They don't although they can postpone a complete breakdown for a while. Usually the effects of applying a restorative compound to a pulley or belt wear off after a few days or weeks and the drive is as bad or worse than it was before. The only really good use for restorative compounds is in removing oil or grease which may have accidently gotten on an otherwise good wheel.

The only real cure for a worn rubber drive wheel is a new one.

Belts are subject to the same sort of hazards as rubber drive wheels. Afterall, they are also made of rubber.

Drive belts can become glazed and dry just like wheels. In addition, a belt can become stretched so that it no longer pulls tightly enough against the pulleys over which it is strung to drive them properly or evenly. This is especially true of machines which have set idle for long periods of time. The problems in cases like this may clear up by themselves after the recorder has run for some time.

Sometimes rubber belts tend to stick to their pulleys. This sticking may cause the belt to squeak. If no other ill effects are noticed, it is best to leave it alone because this also means that the belt is getting good traction or pull. Many times, such squeaks will disappear by themselves. This is one of those cases where experience will tell you what the sounds are like and when to do something about them.

As with rubber wheels, belts can be partly revived with restoring compounds but the effects will not be permanent. If a customer brings a machine in with belt problems, it is better to order a new one and try to explain the situation as best you can.

Usually when belts get very old and dry, they break. Of course, the best replacement for an old belt is whatever belt the manufacturer specifies for that machine. If an exact replacement cannot be gotten, there are some things which can be done for substitution.

Some belts are square in shape. Others are round like a cord. They are designed to fit into tracks or pulleys which fit their shape. A round belt will fit into a rounded groove. The groove for a square belt is a track with squared sides. It is possible to use a square belt in a rounded groove if the belt is the same overall thickness. It is not very good to use a round belt in a square groove because the edges of the groove will wear at the belt. In fact, substitution is generally not a good idea at all and should be used only in a real emergency.

Rounded belts will adjust themselves when placed in their grooves, but square belts must be installed carefully. Be sure that the belt has not turned over while it was being placed. Such twists are just another strain which will shorten the life of the belt. They may even cause enough pressure to flip the belt off of its pulleys sometimes. Simply put it on and then check it from end to end to be sure it is not twisted.

Examine several different friction drive parts. Find some which are new and others which are worn out. Learn the tell-tale signs of wear. Many times it will be possible to physically turn the part in question while it is still in the machine and see how much force it applies to the other parts it is supposed to drive.

Now let's look at some of the problems which can be encountered in a belt drive system in which the belt is properly working.

Belt capstand drive systems are, at this time, the most common type of drive systems found in cassette machines. When working properly they can drive the tape at a carefully controlled speed of 4.25 (4.25 cm per second, 1 7/8 ips). When problems develop, they can drive even a good service technician to distraction. Occasionally, a drive mechanism which seems to be working perfectly will not keep a steady speed. Of course, the motor must be running at a steady and correct speed. However, other things are involved besides the motor. Remember that the motor turns several times faster than the capstand. The flywheel is larger than the motor shaft by a certain ratio determined by the manufacturer. The flywheel must be in good condition, both from a cleanliness standpoint and from a mechanical point of view. This means that there cannot be any dirt or foreign material in the groove where the belt travels. It also means that the bushing and/or bearings which hold the flywheel steady and yet allow it to turn must be in good order. There can be no wobbling or sticking if proper operation is to be had. If, let's say, the flywheel sticks slightly in one place, the following can happen. The flywheel sticks. This puts more strain on the belt for an instant. The belt stretches like a rubber band. The flywheel unsticks. The strain is relieved and the belt snaps back to normal strain. It also snaps the flywheel with a quick jerk, turning it much faster than it is supposed to go. This whole problem has caused the flywheel to slow down for an instant, and then speed up for another quick instant. This jerky action will have a disastrous effect on music and even voice. It is one of the drawbacks to belt drive systems. In other words, the springiness of the belt will tend to magnify any unevenness in rotation of the flywheel.

If the idlers which drive the takeup spindle or fast forward and rewind functions are sticking, they can create similar problems. Remember that anything which is in contact with the flywheel and drive belt can cause problems and should be investigated. A good way to see what is causing the problem is to remove the belt. Place whatever structures you removed back on the machine. Now turn the flywheel and feel its ease of rotation. It should spin freely with no belt attached. Now check the idlers for rewind, fast forward, and takeup. They should not exert any unusual force on the belts. Since there is no belt, you will need to turn them with your fingers. Some cassette machines use the edge of the flywheel as a power takeoff for the idlers. In this case, it will be possible to see what force they put on the flywheel. The important thing is that all these forces must be steady. A problem exists when a wheel is easy to turn in one part of its rotation and hard to turn in another part.

The flywheels and capstands of most cassette recorders are about the same size. They turn at about the same speed. This is about five revolutions per second. This is important to know. If you are listening to music, and the quaver in the notes is about five vibrations per second, you can be pretty sure that the problem is with the capstand and flywheel assembly.

Other problems which may result from worn drive components are such things as failure of the takeup system to pick up the tape, not enough tork to rewind or fast forward a cassette, and speed changes in the tape similar to those caused by any problems with the turning of the capstand or any of its associated parts.

In conclusion, the rubber parts of a friction drive system can cause many problems. Being able to identify bad or worn parts is very important in successfully servicing a cassette machine.

The main disadvantage of belt capstand drives is their likelihood to magnify any problems with rotation.

Be familiar with what happens when various parts of the drive system wear out.

Unit 8

This chapter discusses some of the extra features commonly found on portable cassette machines.

These devices are not essential for operation of a cassette, but make the machines more useful to their owners.

The pause control is one such item. It is simply a lever or series of levers which moves the pinch roller away from the capstand even though the recorder is actually in the play or record operation. The lever will also move the takeup system out of gear so as not to wear out the slip clutch any faster than necessary. The heads still stay in place and the machine electronically works the way it was working before the pause button was pressed. This button is simply there to make it possible to produce smoother sounding recordings or stop the tape on a specific spot during play. Since the motor and amplifier are still running, the tape will start immediately when the pause button is released. The electric power drain when the machine is in pause should be about the same as with rewind and fast forward. The pause controls on portable machines are totally mechanical, but some non-portable machines use electro-magnets to stop the tape. In a battery machine, however, these would use too much power.

The next special feature found on some portables is a key which may be called "Cue" or "Review." The actual name depends on the manufacturer. This key pushes the playback and record head against the tape when the machine is rewinding or fast forwarding. This produces a high-pitched chattering sound which is not understandable, however, it allows the user to find spots on the tape, for example, the end or beginning of a recording.

The next special feature is a counter. Some portables have this feature and many non-portables have it. This is a little meter with three wheels on it. It may look like the mileage indicator on a car. The counter is usually attached to the supply, left-hand, spindle by a belt. The gears in the counter are nylon, usually, and don't make any noise. They are also small and light which contributes to the silent operation of the counter. The drive belt for a counter is usually very thin. It runs to a small pulley on the end of the counter. The wheels of the counter each have a small spike or dog attached to their inside. When the spike comes around, it hits the inside surface of the wheel next to it. It is just like a gear with only one tooth. There is usually some kind of simple drag mechanism on each wheel to keep the wheels from turning by accident when they are not being driven. When the dog comes around, it contacts the inside of the next wheel and carries it around one position. Then it loses contact with the wheel until it comes around again. The second wheel is made exactly the same way and it drives the third wheel. Usually, the only noise heard is a small clicking sound when the machine is in rewind or fast forward.

Sometimes the gears in the counter will jam and this may cause enough drag on the supply spindle to cause problems. Sometimes a bit a spray cleaner applied to the gears will clear up the problem. Never oil nylon gears. Use a solvent type of spray which is designed for such drive systems.

Since the tape counter is attached to the supply spindle, it does not measure the distance the tape has traveled, but rather counts the number of revolutions the spindle has made. This sort of reading is still valuable. The user of a machine with a counter can set the counter to read all zeros at the beginning of a desired spot on the tape. When the user wants to find this same spot, he rewinds the tape until the counter reads all zeros again.

Some of the more expensive non-portable machines have carried the use of the counter one step further with a special feature called "memory rewind." This feature is simply the addition of electric switches to the digit wheels on the counter. When the three wheels are all at zero, the switches on each wheel are closed and an electric circuit is made to an electro-magnet which pulls out the latch holding the rewind button in. In other words, it hits the stop button. Since the tape is traveling very fast during rewind, it may not be exactly at the desired spot, but it will be so close that the user need only look for a few seconds to find the spot. The memory rewind function does not work when the machine is in play or record, at least in most machines. It only works in rewind and only when the user selects that particular function. Otherwise the machine works just like any other cassette machine.

As far as it is known, no portable machines have this feature because of the added electrical drain of a strong enough electromagnet to release a latch.

Most tape counters have some means to reset the wheels to zero. This is usually a small latch which takes the drag off of all the wheels at once. The wheels are outfitted with small springs which are arranged so as to hold the wheel in the zero position. The wheels could also be outfitted with wedge-shaped inner parts which would be pushed by the reset button. If the wheel is showing a number which is less than five, it will turn backwards. If it is showing a number of six or greater, it will turn the rest of the way around. A problem could possibly result when the wheel is reading five since that is in the middle. The wheel might not turn either direction. It is said to be stuck on high center. Usually, this problem is easily corrected by rewinding the machine a little to get the wheel off high center. The lobe-shaped or wedge-shaped parts which return the wheels to zero are commonly known as <u>excentric</u> cams.

Another very common feature which is found in many portables is the automatic shutoff. This feature stops the machine when the cassette is through. In some machines, it is designed to stop the system if the tape jams. In most, however, it is located in such a way that it will only stop the tape recorder when the supply reel, lefthand side, stops. There are several ways to make an automatic shutoff. The expensive non-portable machines use an electronic system which may have a switch attached to a cam on the supply reel. This switch is turned on and off each time the supply reel turns. A timer circuit measures the time interval between switching actions. If it is too long, the tape must have stopped, so the timer sends a signal to the stop mechanism. In some machines, the capstand is stopped. In others an electro-magnet is triggered which throws the unit out of gear just as if the stop button had been pressed. Still other manufacturers, wishing to do away with a mechanical switch cell where the switch and cam were. Light from a small lamp shines on the mirror which is on the supply spindle. The photoelectric cell changes the blinking light from the moving mirror into electric pulses which are timed just like the switch actions were in the first description.

This type of system is good as long as the lamp does not burn out. When this happens, the machine acts as if the tape were stopped when it is not.

There is also another disadvantage to having the shutoff sensor on the left side. If something happens to the takeup mechanism on the right side, or the tape jams in the cassette cartridge, the sensor on the left side will not behave any differently because the capstand is still drawing tape off the lefthand reel. Most manufacturers, however, have more room on the left side so that is where the sensor is usually.

So much for the electronic or electro-mechanical kind of tape stop indicator. Most low-cost portables have a purely mechanical shutoff system. This, again is to save battery power. Usually, these shutoffs work on tape tension. They are, like the electric kind, found toward the supply side of the tape. The tension is measured by a springy finger which pushes through a hole in the front of the cassette and slides against the tape. When in normal operation, the finger has enough spring force behind it to push the tape away from it. When the tape reaches the end of its leader and snags, the tension gets much tighter. Now the tape pushes the finger away. The finger is part of a lever system which is designed to put the machine out of gear just as if the stop button were pressed. This can be done in two ways. One system has a lever located a tiny distance away from a dog or rib inside the flywheel. When the tension finger is pushed away, the lever is moved into the path of the rib in the flywheel. The heavy turning flywheel can put quite a bit of force behind itself as it slams into the lever with a loud thump. The lever is knocked away and into the release mechanism for the button latches. It is possible to sometimes hear the flywheel strike a glancing blow to the lever before it actually trips the shutoff. This will occur just as the machine is shutting off. What this means is that the tape tension had not yet reached high enough level to move the trip lever fully into the path of the flywheel. It sounds like a click heard just a fraction of a second before the shutoff works. Manufacturers design the shutoff this way because the amount of force necessary to trip the release is so great that tape tension alone would not be enough to directly stop the machine.

Another system which is sometimes used is a sort of trip latch. This is an actual latch which is tripped directly by tape tension. This type of mechanism is not as good as the flywheel stop type because it can sometime be tripped by the jerking of the tape when it starts. This has the effect of releasing the play button immediately when the user removes his finger. Providing it is not out of adjustment, this problem can be avoided by simply pressing the start button gently but smoothly so as not to jerk the tape. Both the flywheel stop and latch release type systems work only when the recorder is in play or record.

After reading this chapter, you should have a good idea of the deluxe or extra features found on the mechanisms of most cassette portables. These features are cue or review, which lets a person hear the tape during fast forward and/or rewind, the tape counter which counts the revolutions of the supply spindle and helps in finding a particular spot on the tape, and the automatic shutoff which stops the machine when the tape has ended. Locate as many different models of mechanisms as you can and see how the extra features, if any, work.

Unit 9

Just how are cassettes recorded in stereo?

The answer to this question is simple in theory but rather critical in actual fact. There are a few things a cassette serviceman must know about the stereo recording process in order to make servicing easier.

For the beginning, magnetic tape is the same for stereo recording as for monophonic or single-channel recording. The first cassette recorders used almost half the width of the tape for one track. When the cassette was turned over to side number two, the head recorded the other half. The head in a half-track machine has its magnetic gap located at the top of the slot where the tape travels. This gap is only long enough to reach a little less than halfway down the tape. When the cassette is turned over, the head gap, still in the same place as it was before, is now looking, as it were, at the part of the tape which was on bottom and out of the way before. This means that on a conventional half-track cassette recording, the sound on the top half is recorded in one direction and the sound on the bottom half is recorded in the other.

The gap in the head does not reach all the way to the middle of the tape for a reason. Since magnetism can travel through space, a tape head can pick up signals from a tape even if it is not directly in contact. The signals will not be strong or clear, but they will surely be there.

It is necessary to make sure that the material recorded on the top half of the tape is far enough away from the bottom that this mixing of sounds does not occur. It is similar to a two-way street. There must be some sort of center line separating the lanes of traffic or there will be trouble. The same is true on magnetic tape. The head gap actually misses a little strip of tape right down the midline of the whole strip of tape. This is called the guard band.

In reality, there is some interference between the two tracks but it is so low, thanks to precise construction of even low-price heads, that the user is hardly ever aware of it. If it does occur due to damage to the guides in the cassette cartridge or machine, it causes backward sound from the other side of the tape to be heard along with whatever is on the proper side.

Another way to get backward sound is to have a twisted tape. This can be most annoying because the tape in some cassettes looks almost the same on one side or the other. Remember that the coating of metal compounds is only on one side of the tape. The other side is some plastic film which gives the tape its strength. If the oxyde coating is shiny or the backing side has a flat or frosted finish for some reason, it will be hard to tell. Some tapes have a coating of static resistant material on their back sides which may look like an oxyde coat.

In any case, the backing material is usually thin enough to let the magnetism from the coated side on through to the head. The signals will sound muffled, usually, as well as backward.

It is important to have a good supply of working cassette tapes on hand with material recorded on them so as to determine whether a problem is with a cartridge or a machine.

There is another way to get backward sound or other problems.

Now we get into the discussion of how stereo is recorded on cassette. Stereo, as you may know, is two-channel recording. It is possible to use one half of the tape for one channel, and the other half for the second one. This means that the tape, however, can only be played in one direction. A better way to do it is to cut the width of the tracks in half and get four of them on a piece of tape. As narrow as cassette tape is, it is easy to see how narrow each track becomes. Each track must have a guard band on each side of it also. The electro-magnetic heads must be made with utmost precision. The length of each gap in the head has to be slightly less than one-fourth of the whole tape width. The width of these gaps is microscopic. Each coil and gap assembly must behave the same way as its neighbor so that both stereo channels will sound the same.

Fortunately for the users of cassette machines, a stereo head does not have to contain four gaps. This is fortunate because the cost of a single four-track head can be over $100 (2).

The stereo head works like the mono head. Only a few special types of home stereo or automobile stereo cassette units use four-track heads.

The tracks recorded by a stereo head are actually not side by side as it might seem. One head gap is at the extreme top of the head just as the mono gap was. It covers about the first fourth of the tape. There is then a space equal to one track plus two guard bands and then the other gap can be found. When the tape is turned over to play the second side of the cassette, the two gaps see the alternate two tracks on the tape. If this sounds confusing, think of the four tracks as being like lanes of traffic on a four-lane street. There is one big difference. Unlike a conventional street which would have two lanes going one direction and then two lanes going another, this one would have, say, a northbound lane followed by a southbound lane, another northbound, and finally a southbound lane. The tracks fit together like the dovetail cuts seen in the edges of wooden drawers.

All of this means that if the signals from one track are confused with the signals from the one next to it, the sounds heard will be backward. The most confusing thing that can happen, though, is to try to play a half-track cassette on a stereo machine. One channel will sound alright because the top gap in the head is where the top track is. The other channel, however, will be loud and clear and also backward because the second head gap is actually in the lower half of the tape. Just be sure you know what is recorded on your test cassette.

Playing a stereo cassette on a mono machine will also cause problems. You will hear one track recorded in the right direction and one track from the other side of the cassette recorded in the wrong direction.

As you may be able to tell, it is possible to play mono tapes on a stereo machine if one channel is turned all the way down, but it is not possible to play most stereo cassettes on mono machines.

There is some honest confusion, here. Some stereo cassettes do use the top two tracks to record on. These tapes are compatible with a mono machine because the half-track head will automatically combine the channels. The result will be a fairly good playback.

The four-track stereo recording process is very similar to the monophonic process except for the fact that two track, half the size of the monophonic tracks are used.

Unit 10

Even in the most inexpensive cassette tape recorders, the heads are probably the most precisely made part next to the mechanical parts of the transport or drive system. If you look at the average cassette head, you will see tiny guides built right into the head. These guides must be precisely as wide as the tape. This is a challenge for head manufacturers. On the other hand, the tape must be as wide as most tape recorder guides. This is equally a challenge for tape makers. Some bargain cassette tape is actually good tape which was out too large or too small in width or, worse yet, is uneven. If the tape is too narrow, it can slip up and down in the guides and the head gap will hit a different place each time. If it gets too wide, it will come out of the guides or crinkle, either of which will ruin a recording. The tape must, at all times, be touching the head. Of course, during rewind and fast forward, the head does not need to touch the tape, but during record and play, the slightest loss of contact will be noticeable.

The better manufactured recorders have closer tolerances in their heads, both electrically and mechanically so that recordings are more consistent. The same statement can be true of the makers of recording tape. The saying, "You get what you pay for," was never truer than it is in the recording business.

A mechanical problem related to this is the movement of tape called skewing. This is simply the tape's moving past the head gap at a slight angle. Normally the tape should be at an exact right angle to the head tape. If the guides are too loose or the tape too narrow, it can tilt so as to be touching the bottom guide on the right and the top one on the left. To the eye, it would probably look alright, but even a tiny shift in position will cause an audible difference in the way the machine sounds. Of course, it is impossible to see the tape in the guides because the cassette blocks the view, but any skewing of the tape will show up in the speaker as a very unpleasant swishy sound to the music, or for that matter, voice. Music is hurt worse because the high-pitched overtones of strings, percussion instruments, and some horns are missed more by the ear when absent. This is especially true when the high-frequency or pitched sounds are there part of the time and then fade away. This is the most common effect of skewing.

Briefly, this happens because the head gap is not picking up the magnetic pulses straight on, but rather the magnetized areas are sliding diagonally across the gap. This means that the gap is actually covering a larger area of tape than it is supposed to. The fast-passing bursts of high-frequency sound are smeared together and lost.

The skewing effect also damages recording in the same way. Sometimes, if a cassette recorder is very old and has had lots of use, the guides and heads will become so worn that skewing will take place. If the machine can be repaired by new heads and guides, it may be worth the time. Usually the guides are part of the heads themselves.

Replacement of heads shouldn't be too bad a job if the cassette repairman has the proper tools and test equipment. Tools will include any special wrenches or screwdrivers which may be required to remove the headrack or heads from the machine. Test equipment will include a good quality test cassette, preferably one which is intended for that particular machine, and a volt meter. It may also be necessary to have a soldering iron for many of the lower price recorders.

Some cassette machines, usually the better ones, have small plugs on the wires leading to the erase head and the play-record head. These plugs make changing heads much easier since the wiring to the heads is usually always very tightly packed. Stereo heads will have at least four wires and each one will be almost touching the other.

The connectors usually have a little sleeve of insulation around them to prevent them from actually touching. Handle these little connectors with care since they are broken or sprung very easily. It is not advisable to try to solder a connection like this which was not meant to be soldered because the head may unsolder a vine wire inside the head. If one of the connectors is broken, order a new one or use one from a salvaged machine. Make note of the colors of the wires just like any other electronic servicing operation would require. The connectors can sometimes fit in any way. Don't trust their position to memory. Either make a note or use a schematic diagram. A special purpose stereo head could have as many as eight wires leading to it.

Only use those heads that are recommended by the manufacturer as replacement units. This is for two reasons. One of them is that heads, while they may look alike, can be electrically different inside. There is no law which says how many turns of wire can be in the coil, for example. Some heads have a different sized gap from others depending upon their quality. A low-priced machine may have a head with a larger gap than an expensive one. It also may be true that the engineers who designed this low-priced machine built the circuits to partly make up for the loss in quality. Substituting another head might make the machine playback with a different sound. Some heads are different enough that they might not even work at all. They produce different electrical resistances than the amplifier was designed to handle. Another reason for not using substitute heads is the recording process. The same sort of problems exist here also plus the fact that a high-frequency bias signal is applied along with the sound-frequency signals.

A different head construction would change the level of this bias signal and, therefore, the quality of recording. It could even possibly damage the bias oscillator circuit if the new head drew more current than the old one did. In other words, use only the correct replacement heads.

Now that you have a correct replacement, mount it on the head-rack according to the manufacturers instructions if such exist. In fact, head alignment is one area in which any instructions must be followed closely. If there are no good instructions, do the best you can with the test tape and volt meter.

One caution, be sure that the screwdriver being used to adjust the head screws is not slightly magnetic. This will ruin the test tape.

Test tapes can be bought from many manufacturers of high fidelity equipment. They can be bought in stereo or monophonic. The tapes are usually rather expensive for a cassette cartridge, but you must remember that they are designed for test purposes. They are supposed to be made to the highest specifications. This means that the pressure pad is good and straight, the tape is the proper width, the case is correctly fitted together, and the sound signal on the tape is recorded on a drive mechanism which is as free from speed changes as possible. These changes are called wow and flutter. Wow is a slow rhythmic change in speed. You heard wow if you had a machine with a capstand problem. Flutter is a faster quavor which gives voices and music a watery, gargley sound. A good test tape is not supposed to have enough of either problem to notice. The signal on the tape is usually high-pitched, or at least part of it is. Since high-pitched sounds are the most effected by problems with tape heads or guides, it makes sense to use such a sound as a test. One test tape uses a steady tone of 10,000 hz as the test signal (3).

The meter is to give an indication of the strength of the output signal. If the test cassette has the tone signal recorded full track, it is possible to use it for all types of cassette heads (3).

It is simple to use the test tape if the adjustment screws for the head can be reached. It will probably be necessary to disassemble the case to do this. Hook the volt meter to the speaker or earphone jack and set it for a range of around one volt. Put a cassette of music in first and see if you get an indication on the meter. Listen to the music through the speaker to see if it is not backwards. Turn the screw which tilts the head. You should hear the music get louder and clearer. Many heads have two screws which control the tilt in two directions. One screw may also control a spring which keeps tension on the head base and allows it to give a little in the event that it is accidently struck by a misplaced cassette or by the user during hasty or careless handling. Adjust these screws until the sound is as clear as you can get it. Now put the test tape in and push play. You can probably hear the high-pitched whistle coming from the speaker. Now connect the meter to the speaker terminals or to a patch cord plugged into the earphone jack. Adjust the volume until you get a good reading on the meter. Now start turning the screws again. If everything is as it should be, the signal will probably come up a little more in strength. This means that the head is meeting the tape at the right angle and that it has good contact. If the recorder is stereo, you might see some differences between the two channels. The test tape signal will also seem to change levels a lot if the heads you are adjusting are old and worn. It may even be hard to find the peak if the output changes too widely. This is one good way to tell whether the heads need changing.

Cassette heads, unlike most open-reel head systems are on moving carriages. You have probably noticed this by now. This also means that the heads get more vibration and generally lead a rougher life than the open-reel heads. Even open-reel machines need to be realigned from time to time and this is also true of cassette machines. A rather annoying fact about cassettes is that different cassettes hold their top slightly differently in relation to the heads. This has to do with problems in manufacturing. Even cassettes made by the same company will be different from each other. Using the alignment tape will make sure that the heads are in line with any properly constructed cassette cartridge.

After aligning the heads on a machine, it is good to make sure the screws do not turn from vibration. A little dab of coil dope or even clear nail polish will freeze the screws so that they will not gradually turn. It will not, however, prevent them from being turned by a screwdriver when readjustment is needed.

One or two manufacturers of expensive machines market models with an outside control for head adjustment which is designed to make up or compensate for the manufacturing differences in cassettes. The heads still have internal adjustments, but the external control makes fine adjustments. The technical name for the tilt adjustment on the head is <u>asmuth</u> adjustment.

In summary, while recording heads are delicate precision devices, their replacement is not difficult, although it may be tedious at times. Proper tools and equipment speed up the job and make it more accurate.

Unit 11

Anybody going into the repair of cassette tape recorders should have some idea of how to fix electronic circuits. While this book concentrates more on the mechanics and construction of tape recorders, a little discussion of some of the problems which can be found in amplifiers is in order.

There are many good sources for information on electronic servicing. Books on how to use test equipment and read schematic diagrams cover the shelves of any well-supplied electronics store. What will be done here is to treat amplifiers as basically whole units. A person working with tape recorders should understand what types of systems are involved in the amplifier as well as the drive system.

The amplifier in a tape recorder has to be a sensitive one. It should be able to take a very weak signal and change it into a loud enough signal to drive a speaker or earphone. It is basically several separate amplifiers permanently connected so that the output of one feeds the input of the next. While a tape amplifier has circuits which adjust the frequency or pitch range which it will handle, making some frequencies pass through easier than others, its primary function is to take a weak signal and make it a strong one.

It may be hard to imagine just how weak a signal is involved. Microphones and tape heads produce about the same level signals.

Signals of the strengths being talked about are so weak that they would not even tremble the needle on a standard volt meter.

A single flashlight cell makes 1.5 volts DC. This is almost 1,000 times what a microphone generates in normal operation. We are not talking about volts of electricity when we talk about microphones; it is milivolts. A milivolt is 1/1000 of a volt. The letters mili before anything like volt or meter mean 1/1000 of. The voltage output from a microphone or tape head is AC just like the signal going to the speaker terminals. In fact, the better an amplifier is, the more the output signal resembles the input signal with the exception of being much stronger.

In real life, there are many pitfalls which can happen in the building of amplifiers. This is just another of the many things which separate cheap tape recorders and amplifiers from good ones.

The word distortion when talking about amplifiers means that there is some difference between the output signal and input signal. A study of electronic literature and even some high fidelity magazines will explain where some of this distortion comes from. The most common kind in present day audio amplifiers is called crossover distortion. It has to do with the fact that one or more of the stages in a given amplifier use two transistors to amplify the AC signal. One transistor conducts when the AC is positive and the other conducts on the negative half cycle. It is impossible to make the two transistors match perfectly in the middle and consequently distortion occurs. This distortion is worse during very low signals than during high ones. It really is not any greater as far as the change in the signals is concerned, but it is covered by the fact that the high signal is so much greater than the distortion.

Putting it in other words, a certain voltage range exists in which the amplifier does not handle AC signals in the proper way. This range is from 0 volts to some positive level and 0 volts to some negative voltage. If the signals being fed into the amplifier are strong, this distortion range will only be a small part of the whole signal. If the signal is weak, it may fall completely within the distortion range.

The better amplifiers try to make this distortion range as small as possible.

There are special oscilloscopes which make it possible to see the differences between input and output signals. These are called dual-trace scopes and have two patterns which can be put on the screen at once. It is possible to put one pattern directly over the other and see where they differ.

The other kind of distortion in amplifiers is the more common kind of overloading. While crossover distortion is found in most solid-state present day amplifiers, it is actually not as objectionable as the other kind of distortion. Overloading is simply feeding too strong a signal into the input. Since the amplifier cannot produce voltage it does not have, it simply will not produce any more output voltage after a certain limit of input. If the wave pattern from such an amplifier is put on an oscilloscope, the peaks will be flat instead of their proper shape. The amplifier is said to be "flat topping" or clipping.

A few new amplifier designs are coming out now which use field effect transistors to eliminate the problem of crossover distortion, but the bulk of amplifiers still use the type of circuitry which causes the crossover problem. This, as you may read in electronics literature is because the push-pull circuits as they are called are most economical as far as electricity drain and heat production are concerned.

Another item relating to amplifiers which should be understood is the way in which some amplifiers keep from being overloaded. This is the automatic volume control circuit. In different tape recorders, it goes by such names as "automatic level control," "automatic gain control," and even "level compressor."

The old saying about the names changing but the faces are still the same is true about the automatic volume control. It is used in the record operation to automatically adjust the sensitivity of the amplifier. Some cassette recorders have a switch which allows the operator to either use the automatic control or a manual volume control. While each different manufacturer will probably use different electronic parts and slightly different circuits to make the automatic volume control circuit, the operating principle is the same. Signal is picked up from the microphone input, or another kind of input for that matter, and amplified. The amplifier's out goes to the record head alright, but it also goes into a circuit which converts the AC audio type signal into a steady DC signal. This process is much like that used in power supplies to change the AC house current into DC for operating electronic equipment.

This steady voltage still changes, but more slowly than the audio signal. It is led back to a stage in the amplifier near the input. It may even be the first transistor after the microphone jack. The voltage is used to make that stage and maybe a few other stages more or less sensitive. The higher the voltage, the less sensitive the amplifier. In other words, a loud signal at the input will cause a loud signal at the output which generates lots of voltage. This voltage has a great effect on the input and, as it were, turns the volume way down. This controlling voltage or AGC voltage is made steady and stored at the same time in a capacitor. The capacitor is bled off by the stages it is controlling. Manufacturers try to make this happen fast enough so as to adjust the volume to pick up every word of a lecturer, but slow enough so as not to cause strange effects in the recording. These effects are sometimes called "pumping." This has to do with the fact that the amplifier tends to make the background noise of a room as loud as the sounds which are supposed to be recorded. After, for example, each word of a lecture, the voltage will decay or drop and the stages will become as sensitive as they can. Any small sound in the room will be picked up at possibly the same level as the voice which was being recorded. Then the voice starts again and all the noise goes away for a second. What is heard is an unnatural sounding recording of speech alternating with periods of what sounds like bedlam.

The time it takes the AGC voltage to die away is called the AGC time or AGC constant. Different recorder makers have different ideas on what makes a good AGC circuit. This is why some allow the user to adjust the record volume himself. This is especially handy when recording music.

Those servicing cassette recorders should understand the purpose of all of the connections which can be made to the amplifier circuits.

Remember that a stereo or even a four-channel system is identical to a monophonic system except that everything but the power supply is multiplied by two or four. Portable cassette recorders have a microphone input. Some have no jack for a microphone but have a microphone built into the machine. Some portables have an input called a line input. This input is not as sensitive as the microphone input. It is usually a connection made somewhere after the microphone stage in the amplifier. Its purpose is to handle signals from other sound systems. It is possible to connect a patch cord from one recorder's earphone jack to the line input of another and make a duplicate recording of whatever is on the first machine. Some machines may have a jack which is connected to the output of the first stage after the playback equalization. This jack may be called "Preamp out." It provides a low audio signal which can be fed into another amplifier. This signal can also be fed into the line input of another recorder. Its volume level is unaffected by the playback volume control on the machine. It is also not affected by any tone controls which may be there. This signal, however, will not drive a speaker.

The earphone jack on most cassette machines is simply a jack containing a switch. When a plug is inserted, the switch disconnects the speaker and lets the signal go to the earphone. It is usually possible to drive a small external speaker from this jack. A few machines have a line output. This works somewhat like the preamp output but the signal of the line output is affected by the volume and tone controls.

The same aplifier is usually used for both recording and playback. Each manufacturer has his own clever way of making this action happen. Basically, the tape head is switched for the microphone, and the speaker is exchanged for the tape head. If the machine has one, the bias oscillator is turned on and everything is set to record. All of this switching is actually done by a group or gang of switches all mounted on the same control shaft. Switches like this can be a real headache to the serviceman but there is no easy way to avoid having to use them. The more elaborate machines actually have less elaborate switching operations to do, but they also have more electronic circuitry to make up for it. The schematic diagram will tell you what contacts do what operations on the switch. These switches are usually custom-made and must be gotten from the manufacturer.

On some machines, there is an external connection which, while not actually part of the audio system, must be discussed because it does control the amplifier. This is the external switch jack. It is simply a jack whose connections are in series with the battery or power adapter. This is found most often on portables with external microphones. Some even have a second jack in addition to the one near the microphone connection. This allows the user to use either the microphone to stop the machine or some other outside switch.

The microphones of most portable cassette recorders have two plugs mounted on one handle. The smaller of the two is usually always the switch plug. The larger plug is a standard miniature plug, also used on earphone connections. The small plug on the switch side of the handle is called a subminature. Since some manufacturers use different spacing between the plugs, a microphone from one machine may not fit another. What is frustrating is that the microphones on most portable units are electrically similar. This means that the make from one machine will work on another if the right connections can be found.

The person servicing cassette equipment may have to do some microphone substitution at one time or other. There is no harm that can result in trying one as long as it is connected properly. The worst that can happen is that it will not record properly. Some companies make universal replacements which have the double plugs split into two short branches from the main cord. This makes it possible for one mike to fit several different machines.

The wires which lead to the switch part of the mike plug are very fragile in most mike cords. They rest beside the shielded microphone cable and are covered by the outside insulation of the cord. Usually these wires break before the shielded cable does. Since the switch jack is open when a plug is in it, these broken wires will prevent the cassette machine from operating or they may intermittently make contact if the plug is wiggled. If the customer agrees, the mike switch plug can be cut off as close to the plug handle as possible and the mike can still be used although its switch will have no effect.

The inner mike cable, while delicate, is strong enough to hold a new plug. It is possible to solder a miniature plug on this cable. You should probably explain that it is fragile so that the customer will not get rough with it. It would probably be a good idea to order a new microphone. It will probably arrive about the time the minature plug is broken off. The two wires going to the subminature plug are so fragile, that they will take almost no abuse. If a minature plug is put on the mike cable, it is best just to forget about the switch leads.

Another area of interest in the electronics of portable cassette units is the power supply. Most portables have an adapter for running the machine on house current as well as the usual battery supply. Some portables have rechargeable batteries. These come with the machine and the power adapter does double duty as a battery charger. Some cassette machines must have batteries in them even with the adapter connected because the batteries help filter or regulate the DC from the adapter.

Some machines have an external adapter which plugs into the wall and has another cord with a plug which fits into the tape recorder. Other recorders have the power adapter built into the machine and have a standard line cord with a plug for connection to a wall outlet. There is usually some method to disconnect the batteries from the machine when the power adapter is attached if it is not the charging kind. This is because problems can result if electricity flows from the adapter into the batteries, especially if the batteries are not rechargeable. It could even make a battery leak or even explode. Usually, this method for disconnection is mechanical. The plug which connects the adapter to the recorder is somewhat like the earphone plug which disconnects the speaker. The power plug disconnects the batteries and the machine is run completely by the adapter.

One type of machine has a little relay which closes when the power cord is plugged into an outlet. It is possible to hear this relay click when this is done. It makes no difference whether the machine is on or off. The relay and adapter circuit are electrically ahead of the switch in the recorder. When the plug is pulled from the wall, the relay clicks again and brings the batteries back into the power circuit.

It is also possible to use solid-state diodes to do the same thing. This is accomplished by building the power adapter so that it gives a slightly higher voltage than the battery pack. The wire from the battery pack goes through a diode into the machine. The adapter's output also goes through a diode into the recorder. The diode from the battery pack and the diode from the power adapter are both joined at their same pole, the positive pole for example. The other wire from the battery pack and adapter both go to ground. This circuit does not allow current to flow from the batteries into the adapter or from the adapter into the batteries but it does allow current to flow from either source into the machine. When the adapter is plugged into the wall outlet, it supplies all of the current for the recorder. If the electricity goes off, the batteries will take over immediately.

If a new power adapter is needed for a machine, be very sure that it is able to handle the load and that it is the proper voltage. Some adapters have no DC filtering at all. Be sure that this possibility has been checked also. Some adapters are sold as universal replacements but be sure that the polarity is right. There are two or three standard types of power plugs used for DC. The problem is that some companies use a negative chassis ground and others use a positive ground. Alas, most cassette machines are not protected from power supply voltages of wrong polarity. This can do lots of damage very quickly to the amplifier and even the motor circuits if a wrong polarity voltage is used.

The power adapters themselves are designed to be as inexpensive and small as possible. This is especially true of the external power adapters. They may look like an oversized wall plug with a thin two-color cord leading to a small plug. The box-shaped adapter may have the two prongs of the wall plug sticking right out of it or it may have a second power cord which ends in the normal outlet plug. Inside the box is a small power transformer to step down the voltage and also isolate the recorder from the high voltage, a rectifier or group of rectifiers, and maybe a filter capacitor or two. These items will be nestled together very tightly. The units are usually sealed and, therefore, basically unrepairable.

The power adapters used as battery chargers are built the same except they may not be able to deliver as much current as the power supplies which can fully operate a tape recorder. The battery chargers may not even have filter capacitors but will deliver pulsating DC to the recorder. The recorder uses the batteries themselves as a filter or it may have a filter capacitor to improve performance and reduce hum.

If the power supply is built into the tape recorder itself, it may be a little less tightly packed together than the external kind, however it will consist of basically the same parts. The power supply can be and sometimes is the source of problems which may seem to be in the amplifier so it can be considered as a possible cause of hum or other audio problems.

Finally, the bias oscillator is an electronic circuit which can cause a few problems. This is one case, in particular, where it is best to know as much about the schematic and the theory of machine operation for the particular machine in question as possible. In some machines, the bias oscillator uses the erase head as part of the feedback circuit. On other machines, a separate coil is used as the feedback coil. The high frequency AC signal is fed to the erase head and, in lower amounts, to the record head along with the audio.

On some machines the bias can be adjusted for best recording or for best recording on a different magnetic tape than the kind the machine was originally designed to work with. Follow manufacturer's INSTRUCTIONS carefully. Use the suggested test equipment for the job. This can include a vacuum-tube volt meter or field effect meter, and an oscilloscope. Improper bias can cause bad recordings.

This has been a summary of the kinds of electronics found in portable cassette machines. As you can see, it is important to know what you are working on since electronics is one of the biggest areas of variations from machine to machine. We have not yet even talked about non-portable machines or motors. Look at all the different models of machines which are available for inspection. Look at all the power adapters and chargers you can find. If they are the sealed kind and are not usable because of broken prongs on their AC plugs or some other damage, cut them open and see what is there. Look at the schematics of different machines and see what precautions are taken to be sure the battery power is kept separate from the adapter power.

Examine the circuit boards and schematics to see what kind of bias oscillators the machines use. You may find some with no bias oscillator. These will be the lowest quality portables which use DC erase heads. The schematic will tell you how the circuit is arranged. Find the manufacturer's instructions on setting the bias. These will not usually be in the operating manuals but can be found in service manuals put out by the recorder manufacturers or other private companies which specialize in schematics for electronic equipment.

Unit 12

The motors used in portable cassette recorders are special in some ways. In other ways they resemble any DC motor. One of the things a cassette drive motor must do is provide takeup tension as well as turn the capstand. The capstand must turn at exactly the same speed all the time if the machine is to be any good for recording or playing tape. The problem is that the drag on the motor varies with the condition of the takeup spindle. The slip clutch does a lot to reduce the problem, but it does not eliminate it. Some means must be there to be sure that the motor speed is the same.

Non-portable cassette recorders accomplish this by using what is called a synchronous motor. This is the same kind of motor used in most phonographs, clocks, and other kinds of non-portable tape recorders. It actually keeps its rotation in step with the changing polarity or direction of the house current as it reverses 60 cycles per second or 60 Hertz. By winding the motor differently, the manufacturers can make it turn at 60 revolutions per second, 30, or even 15 revolutions per second. Motor speeds are usually listed, however, in revolutions per minute or RPM. A motor turning 60 revolutions per second is listed at 3,600 RPM. Some motors are even wound so that they can be changed from 3,600 RPM to 1,500 RPM just by turning a switch. They are found often times in open-reel machines.

Non-portable cassette recorders use the synchronous type motors. In portable machines, however, the problem is that no way exists to measure the exact speed of the motor. A DC motor which has no regulation system will simply turn faster and faster with higher and higher voltages. A synchronous motor will just develop more power but keep the same speed.

Most electric motors use a field magnet which surrounds a central core which is the drive shaft. In motors, it is called the armature. The armature usually has some kind of electro-magnets mounted on it so that the field magnet is always pulling the magnets in one direction. In DC motors, the polarity of the field magnet is always the same so the rotating electro-magnets on the armature must be turned on and off as they spin around so that one magnet is always being pulled toward the field coil. This is done with a device called a commutator which is also part of the armature. A commutator looks like a metal sleeve with many tiny slots in it. The parts of the metal sleeve almost touch at each slot. They must, however not touch since they are separate connections. A special springy wire called a brush rides against the sleeve and supplies power to the magnets in sequence as they go around. The brushes and commutator form a kind of switch. The armature of a motor looks kind of like a rolling pin in that its shaft is rather small as it comes out of the motor, but the central part is much larger with the rotating coils and commutator. The central parts of a commutator shaft are primarily iron discs stacked like coins, one atop the other. The discs are cut with large slots in which wire is wound to make the armature coils. There are many other refinements to the art of making electric motors, but this is basically what is inside all non-synchronous motors.

Such a motor can be run on AC as well as DC because the field magnet reverses polarity at the same time as the rotating magnets. When the motor is going to be used for DC and it is not a very large one, the field magnet can be substituted by a permanent magnet. This is what is done in portable cassette recorders. Again, as with many other features, this is done to save the electric power needed to run the unit.

The casing of the motor simply has a couple of permanent magnets with a band of metal to focus the field properly. Inside is a tiny commutator and armature. Such a motor can also be a generator since the magnetic field is there and the coils can be moved by turning the motor shaft. If possible, connect a DC volt meter to the two wires of a permanent magnet DC motor. Set the meter on the 1 or 1.5 volt scale and spin the shaft with your fingers. The needle should jump. If the motor is spun one way, the polarity will be different than when it is spun the other way. Actually the magnets are making AC but the commutator is only allowing part of the cycle to come through. While this is just a passing curiosity as far as servicing cassettes is concerned, it demonstrates something which will come in very handy in understanding how the speed is regulated on some of the more expensive portables.

The motors used in the low-cost portable cassette and eight-track tape players use an electro-mechanical regulation system. It works surprisingly well. There is a special governor switch inside the motor which is connected to the armature. It spins around with the armature and is tugged outward like a ball on a whirling string. When the motor turns fast enough, the switch breaks contact and the motor starts to slow. Now there is less pull on the switch and it closes again. The switch actually stays just in contact so that the speed becomes quite steady. The motor is also helped by the inertia caused by the heavy flywheel. On some motors there is a fine adjustment to allow the service technician to speed up or slow down the drive system. This centrifugal governor is probably the oldest kind of speed regulator for non-synchronous motors.

The makers of modern high-priced cassette recorders, however, use a totally different system for speed control. It is generally called a servo system. If you remember the automatic volume control on the audio amplifier, you can understand the servo system. The motor does not get its power directly from the batteries as it does in the centrifugal governor type motor. The current first goes through a transistor which is physically large enough to handle the motor power. The motor speed is measured by some method and this speed is changed into a control voltage which is amplified, if necessary, and used to feed the motor driving transistor. Such a transistor is sometimes called a pass transistor. The greater the control voltage, the more effect it has on the pass transistor. It acts to turn off the transistor and slow the motor down. A balance is reached where the transistor is supplying just enough current to the motor to keep it at a certain speed. One type of servo system has a special coil on the armature of the motor in addition to the regular magnets. This coil spins under the field magnets and acts like a generator (4).

The electric current generated from this winding is fed into an amplifier which is similar to an audio amplifier, and then fed into the pass transistor where it gradually turns it off. As long as the amplifier functions properly, the motor speed can stay very constant even if the batteries get quite low. Adjustment of the feedback voltage by a variable resistor similar to a volume control is all that is needed to adjust the speed of the tape. Removal of the wire carrying the feedback voltage from the motor causes the amplifier to act as if the motor were stopped and put the full load of the batteries across the motor. The motor then races at two or so times the correct speed. Some of the early servo systems were temperature sensitive and were, in some ways, worse than the mechanical governors in that they tended to slowly increase or decrease the tape speed as the machine ran and the parts on the regulator board got warm. Modern servo systems are, for the most part, expensive but very accurate.

Another kind of servo system used by some makers is one in which the feedback signal is measured in frequency or pitch. This occurs naturally when the armature rotates. If a special coil is wound to act as a generator, its voltage will alternate if it is not fed through a commutator or rectifier. It will act as a tiny replica of the power generation stations which light out houses. The servo amplifier in such a mechanism has a tuned circuit which supplies more voltage when the pitch is too low and less voltage when it is too high. In some machines, a very accurate signal generator produces a signal at the right pitch and the amplifier compares the signal from the motor and the signal generator until the two are equal. Such a system is not very common and is very expensive. The servo motors on most portables are operated more like the first one described in which the speed of the motor changed the voltage going to the regulator amplifier.

The motors found in portable cassette tape recorders are basically of two different types. The centrifugal governor kind and the servo type. The servo type uses an electronic system of speed control while the centrifugal type is electro-mechanical. The electro-mechanical type of regulation is found on the older or cheaper units while the servo control is found on the more expensive machines. Different manufacturers have different ways of design for servo control systems, but the idea is the same, to use the motor's own speed as a control signal for speed regulation.

Unit 13

One of the most frustrating problems a repairer of cassettes can find is the problem of radio frequency interference or RFI. Before discussing different kinds of signals which can cause problems and how to identify them, let's talk a little about how these signals get into the amplifier of a tape recorder.

If an amplifier is exposed to the rapidly alternating current found in radio signals, the connecting wires inside the unit, any external cables, or any electro-magnetic parts such as transformers or tape head coils can act as an antenna to receive the signals. They do this the same exact way the secondary of a transformer converts the magnetic fluctuations or changes in the field of the primary to electricity.

The antennas of many small portable transistor radios are basically a coil of wire wrapped around a piece of pressed powdered iron. Remember that the playback and record head of a cassette machine is basically a coil of wire wrapped around a core of iron. While the tape head is shielded from magnetic fields in the air as much as possible, it is still able to receive some strong signals. Afterall, the gap area of the head must remain open in order to receive signals from the tape. The heads are one of the best ways for stray radio frequency, RF, signals to enter a sound system. The amplifiers in tape recorders must be sensitive. The voltage output of a tape head is about three milivolts (1). This is about 1/1000 of the voltage found at the terminals of a speaker being driven at a good loud volume. The word milivolt means 1/1000 of a volt just like milimeter is 1/1000 of a meter.

Any way you look at it, the voltages found at the output of a tape playback head are so small when compared with the voltages in the power supply system for the recorder or the audio voltage at the speaker.

Any other small voltage at the terminals of the amplifier input will be amplified right along with the recorded sound and will affect it in some way.

How do tape heads pick up radio signals? They do it the same way the coiled antenna on a transistor radio does. Look in the back of a portable radio and you will see a red object which usually runs the length of one side of the case. This red-colored object will have a coil of wire around it. This whole assembly acts like a sort of transformer. The antenna of the broadcast station is the primary while the antenna of the portable radio is the secondary. Think about it just a second and you will see that the tape head is made somewhat like the antenna of the radio. Instead of being red, the magnetic core forms an almost complete ring, but it still is basically the same type of device. Since the tape head is shielded and constructed so that its magnetic pickup is limited to a small specific area, it does not pick up everything in the air. It is, however, able to pick up strong magnetic signals alternating several million times per second.

Many amateur radio publications and some of the hi-fi magazines have addressed themselves to the problem of RFI and how to cure it. Most of the solutions are aimed at solving the problem in high fidelity amplifiers which do not have tape inputs. The schemes involve soldering .05 mfd capacitors across the input terminals to ground, placing more capacitors across speaker terminals, and rerouting wires. Unfortunately, magnetic tape heads and magnetic phonocartridges present some problems in this area. If you have studied any radio theory you know that a capacitor connected to a coil, either in series or parallel, will form a tuned circuit which will respond to one particular radio frequency better than others. If there is a large enough capacitor and coil circuit, this tuned circuit will respond to one audio frequency better than others.

Another thing which must be considered when working with tape recorders is that the high frequency erase and bias signal is actually a low frequency radio signal. If a capacitor of great enough value were soldered across the playback head terminals, it might absorb bias voltage and ruin the quality of the recording. It might also create a tuned circuit during playback which would change the equalization and therefore the sound quality during the playback of all tapes. There is even the possibility that the current drawn by a capacitor across the playback head would damage the bias oscillator circuit during record. In other words, don't put capacitors across the record-playback head unless the manufacturer says it will work and recommends what value to use.

The same problem of creating undesirable audio effects exists to some degree at the microphone terminals especially if the recorder uses a dynamic or magnetic microphone. There is, however, no danger for damage and a .05 mfd capacitor from the mike input to ground might help a problem if signals are getting in through the mike preamp. The speaker output of a cassette amplifier can be handled like any other amplifier output.

Some manufacturers, especially the better ones, will provide a list of procedures to follow when a RFI complaint is received on one of their recorders or other devices. These lists of names, addresses, and telephone numbers can be found in the leading amateur radio and high fidelity magazines. The more a person in the cassette repair business learns about the RFI problem, the easier it will be to solve each new case which comes along. Remember that the customer wants the problem fixed without any side effects. This is why it is good to be familiar with the circuits you are modifying so as to avoid future problems.

Not all RFI is the same or sounds the same. Some people call it EMI or electro-magnetic interference because not all the sources of RFI are radio transmitters. Actually, anything which switches or uses in some other way a large amount of electricity or generates a high frequency alternating current is a possible source of RFI. Let's first talk about the kind of RFI which comes from radio transmitters.

There are two basic kinds of radio transmissions. One is the amplitude modulated signal called AM. The other is the frequency modulated or FM signal. Both types can cause interference with the AM signal apt to be the most audible source of interference. The signals simply generate voltages which are amplified by the amplifier along with the desired taped audio signal. These extra voltages affect the amplifier in different ways depending on the kind of signal which is causing the problem. If the signal is AM, the varying strength of the signal will cause an effect like audio. If the AM signal is from a broadcast station or CB transmitter, it will be possible to clearly hear audio which is being transmitted. If the signal is FM, however, the problem may show up as a sudden increase in distortion in the amplifier or a great amount of background noise. A strong enough signal might even create enough voltage change in some of the transistors of the amplifier to cause them to burn out. Usually, the signal simply is an annoyance with no real damage resulting except to the owner's good humor.

Sometimes even an FM broadcasting station's signal can be heard because metal structures and wiring around the cassette machine might tend to let some frequencies of signal pass more easily than others. As the audio programming modulates the frequency of the transmitter, the signal seems to increase and decrease in strength enough that the amplifier does receive some faint audio. If a customer complains about hearing radio signals on a cassette recorder, it is a good idea to ask what broadcast station is being heard or what other kind of transmission is causing the problem.

Many amateur radio transmitters and some of the more elaborate CB transmitters use what is called single sideband which is considered a form of amplitude modulation. From an interference standpoint, a single sideband signal sounds like static which has the same general sound as a human voice, but is unintelligible. A high powered sideband transmitter operated near a playing tape recorder can produce some terrible racket from the speaker. Amateur radio operators also use morse code.

This is a telegraph-like signal which sounds like a series of pops and possibly buzzes in a tape amplifier.

An unfortunate side to this chapter is that RFI is one of the hardest problems to solve in a sound system. There are endless cases of RFI afflicted sound equipment which refused to be cured. Manufacturers do not generally design enough shielding and filtering into existing equipment to prevent RFI. It would be easy to say that the better equipment is free of this problem but it is just not true. There are endless cases of people buying expensive cassette decks and amplifiers only to hear virtually every CB transmission in their neighborhood. If the CB and amateur radio operators are operating their equipment legally, they cannot be forced to stop. The person who decides to repair cassette tape recorders might do well to try to find out which brands or models of equipment are good at rejecting stray RFI so that customers can be helped if they ask for suggestions on a good machine which would work well. Chances are very good that they will not think of RFI, but you can.

Here are some sources of RFI or EMI which are not transmitters. Many types of electric motors, especially those used in power tools and other home appliances use brushes and commutators like the DC motors talked about earlier. These brushes cause an electric spark and a burst of radio noise each time they make and break contact with a pole piece on the armature. Since this may happen a thousand or more times a second in some motors, the result is a seemingly steady roar of noise. This will create a whining, crackling sound in a tape amplifier.

Electric switches such as relays and ordinary light switches can create single pops and cracks when they are switched. Florescent lights and light dimmers cause harsh buzzing sounds to affect audio equipment. Diathermy machines used in doctor's offices to heat sore muscles can produce noise since they use a radio signal to make the heat. The list is almost endless since anything which switches electricity or uses high voltage is a potential source of RFI. Televisions radiate some signals which can affect a nearby tape recorder. The bias oscillator of one recorder can affect the operation of another machine if they are connected electrically or are physically near to each other.

To a man or woman entering the cassette repair business, this chapter may seem confusing. You may wonder where to start learning about the different kinds of interference and what they sound like. It is not really that bad and gets more understandable as time goes on and experience teaches what to look for when certain symptoms develop. It is just like any other aspect of repair. Sometimes the solution is easy and sometimes not.

Take a working portable machine and locate florescent lamps, motors, and other possible sources of interference. If it is possible, see how CB and amateur radio signals of different kinds affect the machine. It would be interesting to compare two different machines to see whether they are equally prone to interference problems. Even two machines of the same make and model may be different in their response to high-level radio signals.

Unit 14

This unit contains some rather different information from the type discussed so far. We have been talking about and examining the insides of portable cassette recorders. Let us now look at another aspect of the cassette industry. This is the production of cassette tapes on a commercial basis. While most of you will probably be servicing individual cassette recorders, some may be employed in a church or school system. Some large churches and many schools own equipment for producing large numbers of cassette tapes for instructional use. The process of mass duplication is not much different from single recording but it may look enough so to be confusing at first.

First of all, many of the larger duplication agencies do not make their master tapes on cassettes. The master tape is, what its name says, the tape from which all copies are made. Usually the master tape is made on open-reel tape at some high speed which will insure the best possible quality of sound. The tape may be pre-timed by a mechanical device which can be attached to a tape recorder for this purpose. One type of tape timer is mounted on the open-reel machine so that the tape passes over it as if it were a tape guide. The part of the timer which comes in contact with the tape is a delicately balanced rubberized wheel which rolls very easily. The rolling wheel is connected by gears to a counter much like the tape counter on many recorders. The only difference is that this counter is marked in minutes and seconds.

This can be done because the wheel which is being turned by the tape is always the same diameter unlike the roll of tape on the supply or takeup reels. The manufacturer simply designs the size of the wheel and gear assembly to make the counter measure the tape in seconds. It would be possible to make the counter measure the tape in inches or centimeters, or meters, however most such devices seem to be calibrated in time because this is the most useful measurement.

The user of such a tape timer must know what speed of tape the timer is designed for. If, for example, the timer is made to read the passing of one second when 19 cm of tape have gone past the friction wheel, the time will only read a second when the machine has been set to record at 8.5 cm.

One way to make a pre-timed tape is to start with a full reel which will be longer than the desired time, and put the tape recorder in fast forward. When the timer gets near the desired time, stop the machine and move the tape by hand until you reach the exact reading on the timer. Cut the tape and put leader tape on each end. It is as simple as that.

The program to be copied is recorded on the pre-timed tape. The tracks are arranged exactly the way they will appear on the cassette. On some duplication systems, a special signal called a cue is placed at the end of the timed tape. On others, nothing unusual is done.

The machines which actually do the copying are, like the different models of cassette recorders, made for many different purposes. Some small duplicators are little more than cassette recorders with two or three extra cassette drive mechanisms which allow the user to record several cassettes at once in the same way that he would record a single cassette. Still others record at rapid speeds as well as recording all tracks at once. Some machines contain a huge spool of tape which is fed into empty cassette shells and cut when the recording is finished. The machines most often found in schools, churches, and other institutions are not as good in sound quality as those used in commercial recording companies for producing music cassettes. They are designed strictly for voice such as sermons and lectures.

A couple of ideas should be understood in order to comprehend mass tape duplication. One is that the magnetic information on one tape can be copied onto another at almost any speed. The only limitations are the ability of the electronic amplifiers and tape heads to handle the high frequency signals resulting from running tapes at several times the speed at which they were originally recorded. The second concept is that the human brain is the only part of the whole system which cares whether the recording is running backwards or forward. Since at least half the tracks of a cassette are recorded in one direction and the other half in the reverse direction, any duplicator which records all the tracks will actually be recording half of them backwards.

A multi-track duplicator is very much like a stereo tape recorder in that each channel or track has its own amplifier and equalizer. The only thing common to all tracks is the bias oscillator. Most duplicators do not have erase heads. The operator must erase the tapes beforehand.

The drive system of a duplicator is identical to that found in a standard cassette machine except for the fact that one moter may be hooked to three or more capstands by belts. Each capstand turns the same speed as its neighbors. The duplicator may have several cassette wells, each with a record head, capstand, and cassette spindles. Take-up tension is mechanical and may be gotten from the drive belt for the capstand just as it would be done in a cassette recorder. The cassette wells for the blank tapes are called slaves since they start when the master starts and record the information contained on the master. When the master tape stops, a signal is sent to the slave section to make them stop also.

High speed duplicators may run at two, four, eight, or even more times the original speed of the cassette. They may have adjustments on the master deck and slave sections so that master tapes recorded at different speeds can be made to produce cassette tapes at the correct speed. It is possible also to change the electrical connections to the amplifiers so that a track which appeared, for example, as track one can be changed to appear as track two or three on the copies. This feature is necessary because not all tape formats are standard. Some duplicators have provisions to record only certain tracks while others record all tracks all of the time. While it might be possible to disconnect the audio from a track or turn the level for that track all the way down, the bias signal will remain and will partially erase any material which was recorded on other tracks.

Fortunately, most duplications operations standardize on one track format, recording all their masters this way. The operator of the duplicator needs only thread the reel on the master deck, place blank cassettes in the wells on the slave section, push the record and start buttons, and wait for the master to stop. If the speed controls on the master or slaves must be changed, the user will usually also have to reset the equalization controls on each track amplifier. These controls are marked in such a way that the user only needs to be able to match the knob settings with the speeds being used to get proper equalization.

Servicing the electronics in such a machine is no different than any other electronic device except the instructions and service manual may be slightly more detailed and specific about the procedures to use for different service operations. Follow these procedures carefully since high-speed duplicators must be in top operating condition to produce even mediocre recordings.

If at all possible, look over a duplication operation. Try to find one which is large enough to use high-speed multi-track duplicators. See if you can get a copy of the service manual for one of these machines and study it. You will see that these systems are little more than fancy cassette recorders with the same basic principle of operation of any tape recorder. Just like individual cassette recorders, some of the duplicators will be well made with service and reliability in mind and others will be mechanical nightmares with low price their main selling point. If you are ever in a position as a consultant and you are asked to decide what kind of machine to buy, try to get one which is serviceable. Look for electronic sections which can be removed, in other words, modular construction. See how much of the transport system is mechanical and how much is electronic. See whether the adjustments for the electrical and mechanical sections are easy to find and adjust. Look at the test procedures in the manual and see how easy they would be to do. Find out from some other organization who has similar equipment how reliable the equipment and its supplier have been in the past. Even if you are not going to be the usual operator, learn to operate it so you will know what to look for if you are called to repair it.

Unit 15

So far we have studied the portable cassette recorder almost exclusively. Now let us look at some of the non-portable machines and what can be found which is different from the portable units.

The motors in most, but not all, non-portable cassette tape recorders are the synchronous kind which means that their speed is governed by the electricity's alternating current frequency. Such drive mechanisms cannot be adjusted as to speed, since the motor always keeps the same speed. If speed problems develop, they are usually a result of mechanical problems within the motor, belt, capstand, or other associated parts. One of the things which can happen to a synchronous motor is for dirt and/or grease to get into the bearings at each end of the shaft and drag the motor so heavily that it can no longer keep its speed. This sort of thing can happen over a period of years or it can be caused by improper oiling of the shaft. A person should be exceedingly careful when oiling the shaft bearings of a synchronous motor. In the first place, it should be known whether or not the shaft is supposed to even be oiled at all. There is no real rule of thumb for this. It will be necessary to have a service manual for the particular machine in question. If oiling is required, it is usually done very seldom. Some sort of dropper or other measuring device should be used because it only takes just a bit to do the job. Any more and the motor will run slowly or even fail to start. Another thing which can happen is for the bearing to become out of round from uneven wear.

Shaft bearings usually ride on a central post and roll between the motor's driveshaft or armature and the housing or bushing which is found at either end of the motor. The hole in the bearing is usually as round as can be made so that it will roll as smoothly as possible. If the hole was made a little too large or the center post a little too small, the bearing can wobble around as it turns. This will tend to make the center hole egg-shaped and uneven. The bearing can then bind in one position, refusing to turn or it can rhythmatically wobble as it spins and cause a terrible squel which is unmistakable to anyone who has heard it once. It sounds like a wale which may change pitch over a period of time, perhaps a few seconds or so. It may even disappear after the motor has run for a while. Usually in a case like this, the motor runs a little slower when the bearing is not turning right. It may seem to clear up and run right or it may suddenly freeze. It all depends upon whatever chance happenings take place in that small space between motor shaft and roller bearings. A small amount of oil may clear up the problem temporarily, but experience has shown that such a motor is doomed and should be replaced with a new one.

A bad bearing can also make a steady, growling sound. This sound is not as loud and startling as that from a wobbling bearing. In fact, the sound may be hard to recognize if one is unfamiliar with the particular make of machine. This problem may be cured by careful oiling of the motor shaft with very light machine oil. Needless to say, it is very important not to get any of the oil onto any pulleys, belts, or other friction drive parts. A little shot of spray cleaning solvent on the bearings before the drop of oil is applied will insure that any dirt which may be there will be washed away.

The small DC motors found in portables do not usually get the kind of problems described here because they are more tightly sealed and do not seem to collect dirt like the synchronous motors. It is also due in part to the fact that most synchronous motors have a fan mounted on the shaft to blow a stream of cooling air over the motor windings. The stream can also have any dust which happens to be floating around. This dust will eventually cause the clogging and other mechanical problems discussed. Since oil tends to hold dust, more oil than necessary will attract dust faster than usual.

Find some old synchronous motors out of record players and tape recorders and take them apart. While they may look different one from another, you will probably notice that they are more similar inside than different.

Some non-portables use the synchronous motor to do all the work just like the portables. The mechanisms of these AC powered units are basically like the portable, single-motor machines. A few small changes, however, will be noticed. Since there are no batteries to run down, the power is left on even when the stop switch is pushed. The capstand still turns but it does not pull any tape due to lack of the pinch roller. The takeup tension is gotten from the same mechanical system found in the portable machines. The rewind and fast forward functions are also run from the main drive motor. The machine may be larger than most portables with more features and slightly more expensive than some portables.

The machine may have an automatic shutoff. This can either throw the transport system out of gear by activating the same release mechanisms which are tripped by hitting the stop key, or it may do something similar to putting the machine on pause by activating an electric solonoid or magnet to pull the pinch roller away from the capstand. This feature will also more than likely move the takeup tension system out of gear also. The solonoid will stay in the pause position until the user pushes the stop button and takes the transport mechanism out of gear. The mechanism for operating the stop solonoid may be photo-electric or electro-mechanical. There is a wide variety of schemes in AC powered cassette machines for automatic stop compared to the limited number of systems in portables. This is because the manufacturers do not have to worry about batteries and enough power to run everything.

There is another basic kind of AC powered machine. This is the two-motor transport system. In this system, a synchronous motor is used to drive the capstand and takeup spindle, while a second motor, possibly a DC motor, is used to control the tape during rewind and fast forward only. This motor does not have to be regulated. All it needs to be is fast and powerful. It is used to operate a set of mechanical friction drives and belts similar to the single-motor system. The only real mechanical difference is that there is no idler pulley on the drive belt or the flywheel to use the power from the capstand motor. The second motor does all that work. The capstand motor can be somewhat smaller since it does not have as big a job in the two-motor machine.

Another major type of AC powered cassette tape recorder is the three-motor type. This machine uses a separate motor for the capstand drive, fast forward, and another for rewind. The rewind motor turns clockwise while the fast forward motor turns counter-clockwise. The capstand drive motor turns only the flywheel. Takeup tension is produced by feeding a little electric power to the fast forward motor so that it tugs on the takeup spindle with a nice even pressure. Electricity to the motor is controlled by a variable resistor which can be adjusted to provide different strengths of takeup tension. With reduced power, the motor cannot develop the tork or turning power needed for fast forward. When the machine is set to fast forward, the resistor is switched out of the circuit and the full power is applied. Also, in a machine like this, it is very easy to have a little controlled drag on the supply side. This is done by applying some current to the rewind motor while the machine is in record or play operation. This makes the tape flow more smoothly over the heads.

The mechanical controls such as the movement of the heads, brakes, and pinch roller is accomplished by electro-magnets. The electro-magnets can be controlled by electronic switches so that the user cannot break the tape by pushing the wrong series of buttons too rapidly. The main advantage to a system like the three-motor drive system is that a good deal of the complex and sometimes frustrating mechanical devices have been eliminated by this almost totally electronic approach to the mechanism.

Some of the most expensive and elaborate cassette machines use the three-motor drive system. A few of them use a DC servo control motor to run the capstand. There are even some which have a device to measure tape tension. The signal from this device feeds the takeup and drag motors so that they can continually adjust the tension. This is a servo mechanism also.

Getting back to the mechanical one- and two-motor systems, another type of mechanism is also found. This is the automatic reverse. It allows the user to get almost uninterrupted recording or playback time from both sides of a cassette without turning the cassette over. The machine senses the end of the tape, reverses, and records or plays on the bottom half of the tape.

A machine which has automatic reverse must have a record and play head containing all the tracks to be used. This means that a stereophonic head must have all the more tracks represented on its face. During the playing or recording of the first side, the head works like a normal tape head. The bottom two recording gaps are not used. When the automatic reversing system operates, the top two track gaps are switched off and the bottom two are switched into the circuit.

The mechanics of the automatic reversing system are a little more complex. In order to reverse, a second capstand and pinch roller are fed through the hole in the cassette to the left of the erase head. The second capstand turns in the reverse direction from the first or righthand capstand. The pinch roller for the righthand capstand is actually mounted on a platform having a triangular shape. The platform is on a swivel base which allows it to turn either to the right or left. The right pinch roller or the lefthand pinch roller can be engaged simply by swiveling the platform one way or the other. The platform is mounted so that both pinch rollers cannot be engaged at the same time. It would be similar to touching the left hand with the right thumb and then touching the left hand with the right index finger simply by turning the right hand slightly. There must also be a second takeup tension assembly for the lefthand or supply spindle.

Most portables do not have the automatic reversing feature. As you can see, the automatic reversing feature is mechanically quite complex although it is just an extension of the basic tape drive system. The tape recorders with three-motor drives can accomplish all of these mechanical tasks much more easily. The only extra device added is a second capstand and pinch roller. This second capstand may be driven by the capstand drive motor which drives the righthand capstand or it may have its own motor. Some cassette machines have a special tension system whereby the second capstand is engaged at the same time as the first one. It runs at a slightly slower speed than the first one, causing the tape to be stretched tightly over the heads. When the machine reverses, the two capstands are reversed in direction and the righthand capstand, the one which had been leading before, now follows the lefthand capstand.

The type of system where one capstand pulls the tape and a secondary one supplies the drag is known as a dual capstand drive system. It does not necessarily have to have automatic reverse. Units with dual capstand drive are among the best of the best and the average person in the repair business will probably not see very many of them. The three-motor drive systems without automatic reverse are also expensive but somewhat more common.

Remember that on an automatic reversing machine, both supply and takeup spindles have tape end sensors since the two spindles actually switch roles. The takeup spindle becomes the supply and vice-versa. When the first side is through, the end sensor, instead of stopping the machine, trips whatever mechanisms are present to reverse the tape and the takeup tension. When the other end is reached, the second tape end sensor shuts off the machine. This type of system is also found in automobile cassette machines (1).

One of the best ways to learn about the top-of-the-line cassette transport systems talked about in this unit is to read all of the new equipment reviews which come out each month in the high fidelity magazines. These reviews do not usually go into depth on the electronic and service aspects of the machines reviewed, but they do provide useful information about what sort of new systems are being used by manufacturers. A good repair technician should always keep up with the latest products so he or she will not be caught by surprise by some new machine someday. While it is difficult to understand the whole operation of a machine from an equipment review, the reader may realize that he must study about this new system so as to be ready for it when one is brought into the shop.

If possible, visit a high fidelity dealership's service department where you may look at the insides of the most expensive equipment. While virtually no mention has been made in this unit of the electronics involved, try to learn about the electronic differences between the portable and non-portable units. Don't look at it from a circuit view: rather look at the features such as external connections, amplifier power, and controls. Study the electronic schematic of a machine only after you know what the different controls and features do. This will lend some sense to, what might seem, a bewildering maze of systems. Basically, the portables have the same types of amplifier and bias circuits as the non-portables. The only real difference being that the non-portable units will probably have heavier audio output stages and larger, heavier power supplies. While some cassette units have elaborate mechanical control systems such as automatic reversing and servo tension control, others might have a very basic drive mechanism and quite complex amplifier and noise reduction systems. The top-of-the-line machines usually have both. You will find, however, that the complex machines are simply just another step on the ladder from the mechanisms of the portable machines.

Another seldom-seen but important area in the cassette recording field is that of special formats and equipment. Because of the nature of this area it is virtually impossible to list all of the special uses which have been found for cassette tapes and equipment. The Phillips Company has required that all manufacturers who sell cassette machines must make those machines so they produce a recording which can be played on any other machine (1). This does not mean, however, that the machines cannot be used in new and different ways.

Probably the most common cassette format besides the usual monaural and stereo system is the type of system which can play a tape and control a film slide projector at the same time. Such systems are called slide-sync systems. One type of system records the regular voice program on side one of the cassette and puts the electronic control signals on side two. This means that the cassette can only be used in one direction with this machine. If it is turned over, the control signals will be heard in the speaker and the program will be on the control side and therefore inaudible.

The amplifier in such a system is just like a stereo amplifier. One channel ends in the usual speaker for the program while the other channel ends in a special filter which can receive sound of a certain pitch. The electronic control signal which changes the slide is received by the filter. The filter operates an electrical or electro-mechanical relay which tells the projector's slide-change system to operate.

There may be more than one tuned filter in a slide-changing machine. One type of machine uses a 1000 hz beep tone to change the slide and a 150 hz deep tone to stop the tape drive after the last slide. This feature allows the operator to possibly put more than one slide series on a single cassette (6).

Other manufacturers use a low-pitch tone on the same track as the program. This tone is low enough in pitch that it is not objectionable. The slide-change mechanism simply has a good filter which makes it possible to screen out all the rest of the program material except the tone. The only drawback to this kind of system is that some of the program material may be at the same pitch as the tone. If this pitch stays there long enough, the machine will act as if it received a switching tone and change the slide.

Other slide-sync systems use stereo cassettes. The two inside tracks are for the tones with the outside tracks used for the program material. If such a cassette were played on a stereo machine, one of the two channels would sound natural. The other channel would be silent except for beep tones when the slides were supposed to change. Such a system can get as much recording time per cassette as a standard system. The cassette can be used on both sides also.

The beep tones don't necessarily have to operate a slide projector. They can be used to do anything desired: switch slides, operate electronic equipment, stop the machine, etc.

Another area in which special formats are used is that of recorded books for the blind and physically handicapped. While cassette recorders cannot be sold which can record at any other speed than 4.25 cm per second, machines can be made which can play at any speed. In the case of recorded material for the blind, good voice quality is all that is needed. This means that a slower speed can be used which will allow more material to be put onto a cassette. The Library of Congress has decided to use the speed of 2.125 cm (15/16 inches) per second as this new speed (8).

The Library of Congress is also in the process of equiping all of the users of the special reading material with machines which can play four-track cassettes. These specially made machines are not stereo machines. The heads are connected to a switch which allows the user to select either of two tracks. When the tape is turned over, the other two tracks are selected in the same manner. This allows twice as much reading material to be put on a single cassette cartridge. Since the speed is also twice as low as normal cassette tape speed, the net effect is to have four times as much playing time as could be had on a standard cassette system. In addition, the four tracks are arranged so that they interlace. Track one, for example, goes the same direction as track three. Track two is recorded in the same direction as track four. If such a cassette were played on a stereo cassette recorder, the speed would be wrong to begin with plus the user would hear one track in the right direction and the other track or channel would be in the reverse direction.

Some of the cassette machines made for playing the special four-track tapes can record, but they will only record at the normal cassette speed. When the speed selector is in the 2.125 cm position, the machine's motor is disabled when the record button is pressed. This satisfies the legal requirement that the machine be able to record cassettes which are compatible with other cassette recorders (9).

Since no cassette recorders exist which can make four-track tapes at 2.125 cm, how are they produced? The answer lies in the duplication process. If you remember, commercial duplication equipment can be made to accept master tapes recorded at different speeds. There are speed controls on the motor sections for the master and slaves to make it possible to produce cassettes recorded at the correct speed. Even though the duplicators are not designed for making tapes at 2.125 cm per second, this can, nevertheless, be done quite well by deliberately setting the slave unit on the next lowest speed down from the one it should be on. This is because all of the tape speeds used today in audio recording are arranged so that each speed is twice as fast as the one below it. Some of the common audio tape speeds in use today are in metric: 2.125 cm, 4.25 cm, 8.5 cm, 19 cm, 38 cm, 76 cm, etc. In inches that equals speeds of 15/16, 1 7/8, 3 3/4, 7 1/2, 15, 30, etc.

Most of the master tapes made for non-critical voice recording are recorded at 8.5 or 19 cm per second. Good voice recordings can be made with the proper equipment at 4.5 cm however this is not desirable because too much quality is often lost in the duplication process.

With the development of small computer systems, cassettes and ordinary cassette recorders are being used in some areas for storage of computer data. As far as the repair of cassette recorders is concerned, this type of operation should be treated just like the recording of music or voice. In fact any kind of electronic signals whose frequency range falls within those frequencies which are good for voice or music can be stored on cassette.

This unit has attempted to describe some of the special formats which may be encountered in the repair of cassette equipment. If possible, it might be a good idea to tour a state library for the blind and physically handicapped and look at the special cassette equipment on hand. Try to examine a slide-sync machine. When you do this, learn how the tone signals work and how the tape is made. Of all the special machines you might see, the slide-sync system is probably the most widely used. Many schools and public libraries use them.

Unit 16

In every unit of this manual, the words "usually" and "most of the time" appear quite often. This is because makers of cassette tape recorders, just like the makers of any other mechanical devices have only their imaginations as the limit to the different ways things can be built. In your examinations of various cassette machines, you have probably noticed a great deal of similarity in their internal design. Some machines are virtually copied from others. Still other machines are actually made, at least in part, by companies other than those whose names appear on their brand labels. This is done for economic reasons. One company may be very able to produce huge numbers of electric motors or amplifiers at a very low cost. Another company may have a large plant for making plastic cases. Still another specializes in rubber products such as belts, tires for friction wheels, and groments which cushion the sharp edges of chassis holes where wires will pass. Another company may specialize in speakers.

In short, very few but the largest companies can or would even try to make all of their parts themselves. Usually, the company circulates invitations or bids to other companies for whatever parts are needed. The company which can provide the part at the lowest price will get the contract. The final assembly is still done by the company whose name appears on the unit, but most of the parts and subassemblies probably came from other manufacturers.

The process is simply a large version of the familiar practice of going to the hardware store and buying the parts to build a shelf or a cabinet latch.

This practice of contracting work has led to some degree of standardization even in mechanical parts. It is sometimes possible to visit a large electronics or high fidelity parts store and find a large rack of belts and pulleys for use in phonographs and tape machines. The chances are very good that a universal replacement part, if it is exactly the same size and appearance as the worn part, will work perfectly. It may have even been made by the same company which made the original one. Be very careful, however, to check every detail of the new part. Make sure that it is not, in fact, only similar but not exactly the same. Such things as pulleys and flywheels must be precisely the same size to insure proper tape speed and/or clearances with other parts. If, say, a pulley were found which was slightly larger than the original one, it might not behave properly in relation to the other mechanical parts which are driven from that pulley.

It cannot be overstated, however, that any general statements made about cassette mechanisms have their exceptions. In this manual, brand names are avoided as much as possible since different companies produce new and different models every year. What may be found in one machine this year, may appear in several others next year. The original maker of the device may have found something else which works better and so may have discontinued its use.

Here are some examples of some peculiar mechanisms which may be found in cassette tape recorders. They may look a little confusing at first, but examination usually reveals that these strange mechanisms are just as easy to trouble-shoot as the familiar ones once the operating principle is known.

Most cassette tape machines which have a pause control create the pause operation by pulling back the pinch roller from the capstand and releasing the takeup tension mechanism. This is all done by a series of levers connected to the pause button. Some machines may use a solonoid to do this, but the basic idea is still the same. At least one make of cassette recorder has a different approach altogether. In this machine, the capstand and flywheel are not one solid unit like the great majority of capstands. The capstand in the unit being described fits into the center of the flywheel by means of a center post. The center post turns freely inside the flywheel and the two items, by themselves, cannot turn one another. The flywheel can turn freely in both directions when held on the center post of the capstand. The flywheel, however, has a center hub. The capstand's center post fits down into the middle of this center hub. The center post of the capstand abruptly gets much larger and makes cylinder the same diameter as the center hub of the flywheel. The cylinders of the center hub and capstand body are both machined very smoothly. A special spring is is placed between the capstand and flywheel so that it wraps equally around both parts. When the capstand is turned in one direction, it wraps the spring tighter and locks both capstand and flywheel together. If the flywheel turns in the opposite direction from that which was described above, the spring is unwound and no longer can grip the two parts together.

The whole process can be demonstrated by taking a piece of paper and making a roll out of it. Put a finger in each end of the roll and twist in the direction that the paper is wound. You will notice that the roll tightens on your fingers and makes a solid connection between right and left hands. Now twist in the opposite direction and loosen the roll of paper. The connection is lost. The spring works exactly the same way. The spring in this particular recorder has a little bit of the last turn of wire bent out straight. This makes a sharp spike which fits into a little rubber-tired wheel which has a slot for this purpose. The wheel sits right over the center of the flywheel at the base of the capstand. It provides a method of stopping the rotation of the whole assembly above the spring. In other words, the flywheel can still freely turn, but the capstand does not turn because the spring is being partly unwound.

The whole assembly looks like a standard capstand and flywheel except that a little rubber wheel is around the base of the capstand where it fits into the flywheel. When assembling such a clutch mechanism, the technician must hold the flywheel in one hand and grasp the capstand in the other. It is possible to turn the flywheel freely in one direction, but the capstand must turn along with the flywheel in the other. It may feel like turning a rachet wrench without hearing the clicking of the rachet. If the assembly slips or tends to bind in both directions, it has probably been incorrectly assembled or may need lubrication on the metal-to-metal surfaces. An example would be a case where the capstand locks with the flywheel in one direction and trys to lock in the other direction. It might also fail to tighten with the flywheel when turned in either direction. Usually this is because the two cylinders which make up the hub of the flywheel and the base of the capstand are not meeting exactly. They cannot go to one side or the other because of the center post joining capstand to flywheel, but they can be slightly apart, leaving a gap between the two. In this case, the spring will try to wind inside the gap and the assembly will not work right. In the machine described here, the takeup tension comes from an idler wheel placed against the larger section of the capstand. When the capstand stops, the tension stops also.

The device which stops the capstand is a little solonoid which presses against the rubber wheel whose key slot snags the end of the clutch spring. This mechanism has the ability to start and stop the tape with incredible speed. When it is working properly, it is not possible to hear any wow or flutter resulting from starting or stopping the tape. The sound simply comes on or goes off like it would when an electrical switch is used to shut off the speaker.

Another brand of recorder, commonly used in slide-sync systems and other educational hardware, does not use belts to drive the flywheel and capstand (1). It uses a special friction drive between motor and flywheel vaguely similar to that used in phonographs. It is supposed to be very accurate in speed and almost free from wow and flutter. The flywheel is actually larger at the base than at the top. Rewind and fast forward functions are obtained by slightly lowering the spindles so they touch part of the outside of the wheel. This is called a byperipheral drive system by its makers (1).

Most tape stop mechanisms use either a photo-electric cell, a switch which turns on and off with the rotation of the supply or takeup reels, or a tension sensor which mechanically throws the drive system out of gear. One make of machine has a different type of automatic shutoff. It is purely mechanical and works from the takeup reel giving it the advantage of being able to tell when the cassette has jammed. This shutoff system consists of a couple of gears and a large plastic lever behind the gears. The lever somewhat resembles the earpiece of an eyeglass frame. The crook of the lever is right behind the two gears. The gears are both the same size. The one farther back from the front is fixed in one position although it can turn freely. The other gear is on a swingable arm which allows it to turn around as well as travel around the outside of the first gear. Normally this planetary-type gear stays with its arm pointing to the front of the machine. When the slippage in the takeup tension reaches a great enough point, a felt wheel pushes the gear on the swinging arm around the center gear like the moon rotating around the Earth. It travels around this central gear until it runs into the plastic lever behind the gear assembly. This lever has its other end next to the release latch which will cause the machine to go into the stop function. When the lever is hit by the traveling gear, it, in turn, hits the release and the machine is stopped. When the machine has stopped, there is no more pressure on the felt clutch and the roving gear swings back around to its normal position by the aid of a spring. Such a system seems to work well, although it could cause problems if the tension of the springs changed or the felt clutch became badly worn.

Automobile cassette players have a conventional cassette mechanism except the capstand drive mechanism, motor, and cassette spindles are on a movable platform which is designed to drop down slightly when the cassette is through. This is so the cassette can pop out of a slot in the front of the machine rather than require the driver to have to open a door, lift a lid, or do any of the other more conventional actions for removing or replacing cassette tapes. The act of pushing a cassette into the slot causes the subchassis to come up to meet the cassette. A solonoid is tripped by the tape end sensor to drop the tray or chassis back down and eject the cassette. Many car cassette players also have automatic reverse. This is done electro-mechanically. When the first tape end sensor trips, the four-track playback head is switched to the two bottom tracks, the dual pinch roller platform is flipped so that the lefthand pinch roller is now against its capstand, and the takeup tension is fed to the left spindle instead of the right. The second tape end sensor trips the release solonoid which pulls out the latch holding the subchassis up. It is dropped by springs and the cassette pops out (1).

The auto cassette mechanism is known as the Starr system (1).

In this chapter, we have explored some of the deviations from normal which occur in the design of cassette recorders and players. There will probably be more as time goes on and those described here will probably show up in machines of different brands. Try to find machines which have these differences in them. Learn how they work and what happens when they don't work. Remember, it is much easier to repair a mechanism if one has some idea how it is supposed to work.

Unit 17

In this unit we will look at the wise use of tools and test equipment. Anyone who has taken an electronics course has probably seen the usual standard test equipment such as oscilloscopes, volt ohm meters, and vacuum-tube or field effect transistor volt meters. It is not enough, however, to learn how to adjust the controls to use the meter or scope for a particular purpose. A good repairer must know how to interpret what is on the dial or screen. A good technician can learn a wealth of things from mediocre test equipment while a poor technician will be completely lost trying to use even the finest equipment. There are several good books available on using meters and oscilloscopes, however, the best practice is actual practice. Learn what equipment gives the most reliable results doing particular tests. Take an oscilloscope, for example. This useful device can read frequencies, analyze signals, measure voltages, and pinpoint interference. The problem is that its visual indications are just that, visual and it may take some time for a technician to learn how to relate what the screen shows to what the ear hears. This is why certain tests are probably better made with a scope and others should be made by using a device called a signal tracer.

A signal tracer is basically an audio amplifier with a very high input resistance or impedance like a vacuum-tube volt meter. It may also be equipped with a meter to give some idea of relative signal strength, in other words it may allow the user to compare one signal level to another. Some signal tracers have sensitivity ranges which allow users to read extremely strong signals, such as speaker outputs, and yet still be able to read weak signals, such as microphones or tape head outputs (1).

These devices contain a test probe like a meter and are used in much the same way. They usually have a speaker or headphones which allow the signal to be heard just as it appears at the circuit being tested. It is possible, using a signal tracer, to listen for noise or distortion. The ear can hear some forms of distortion more easily than the eye can see them through a scope (1). In any case, time will educate the ear of a good technician so that he or she may be able to recognize certain symptoms as being caused by certain defects. For example, audio, before it is de-emphasized, has a very reedy, tiny sound. If the service technician uses the signal tracer to follow the signal through the playback amplifier of the recorder and the audio retains that tiny sound past the de-emphasis network, there is probably something wrong there. Be familiar with your equipment. Know what the signal tracer, for instance, sounds like when properly equalized audio is fed through it so you will know when what is being heard is not right.

A volt meter, be it a standard DC type or a vacuum-tube or field effect type meter, has jobs which it does better than other instruments. Mainly these jobs are those associated with reading relatively steady voltages such as the DC bias on transistors or, for that matter, the AC bias used in erase and record functions. One should be aware, however, that high frequency AC such as erase bias should be read with a meter which is supposed to be able to handle such a signal.

Audio can be measured with most volt meters. Since the level of a sound signal varies, the reading may be a little difficult, but the meter can give a good idea of the general voltage levels involved. Don't forget, though, that the meter can tell nothing about the quality of the audio and that some means should be used to do so if there may be some question.

Let us now look at a piece of equipment which is coming into use more frequently as time goes on. This is the digital frequency counter. While there aren't many jobs such a device can do in the servicing of cassette tape machines, there are a few that a frequency counter can do better than almost any other piece of equipment. A frequency counter works basically by allowing an electronic circuit to count the number of pulses going into it over a measured length of time. After this time is over, the number of pulses is fed to a number display where it can be read. The counter circuit is set back to zero and another count can be taken. If, for example, the counter is set to take one sample per second, and the test probe is connected to a signal whose output is supposed to be 1000 hz, the numbers will read 1000 after one second has passed. A good frequency counter has a very accurate clock inside it to operate the reset for the counter circuit. Frequency counters usually have different ranges on them so that the counter can take samples of different lengths. Frequency counters like pocket calculators are much cheaper than they used to be and a counter suitable for the kind of work used in cassette machine repair can be had for around $100.

A counter could make it possible to check the speed of a tape recorder by playing a test tape which contains an accurate test tone.

All that is necessary is to feed the audio from the output of the amplifier into the input of the frequency counter. Put the counter on the appropriate range and read it. It may be difficult to get the counter to read the exact number, but it should be possible to get the reading within a few cycles of the correct number. Be sure that the test tape being used is designed for speed tests. One way to do this is to see whether there is any information about how closely the frequency of the recorded signal should correspond to the advertised frequency. This would probably be written as a percentage of the test frequency. If, for example, the manufacturer of the test tape says that the tone should be within .1 percent of the stated frequency, you can be pretty sure that this tape is suitable for adjusting tape speed. If, on the other hand, no figures are given for the accuracy of the tone frequency, the tape might be fine for adjusting heads, but not good for adjusting speed.

The frequency counter, of course, must be checked occasionally and this should be done as the instructions require. Most frequency counters are good enough for audio work. A good counter is not even as expensive as some of the more precision oscilloscopes.

A frequency counter can be used to check bias frequency. While the frequency of the record and erase bias oscillators is not extremely critical as far as erasing tape is concerned, the frequency may be critical in another respect. There are tuned circuits called traps in some recorders which filter out the bias signal and keep it from flowing into the audio amplifier where it would do lots of undesirable things. These tuned circuits are able to pass audio signals, but do not pass the above audio bias signal. If the bias oscillator changes frequency, it may be able to send signals through the traps anyway. Either the trap or the oscillator must be readjusted. The specification sheets for a given recorder will explain how to do this.

Another type of volt ohm meter which has recently come into use is the digital volt meter or DVM. This simply converts the voltage or resistance reading from a voltage or resistance to a digital display just like that of a frequency counter. It should be used just like a conventional volt ohm meter or vacuum-tube volt meter, VTVM, or field effect volt meter, FETVM. The instructions should tell whether it is capable of being used like a VTVM or FETVM.

In order to really do a good job on repair, it is necessary to have a good collection of tools. While tools represent a sizable expense, they can return lots of money by making it possible to do a wider range of jobs than could be done if a particular tool were not there. Take a simple thing like a screw starter. This tool has a tip somewhat like a screwdriver. The screw starter tip, however, has some mechanical device which makes it able to hold the screw firmly enough for the repairer to sneak it into a tight spot. Many small recorders are famous for having screws in just such places. Let us say that the tool costs $1 and you are getting $10 per hour. It might take 10 minutes to start a screw which is just out of reach. That is a dollar right there. It might take five seconds to do the same job with a screw starter.

The same is true with soldering and desoldering tools. Using the right kind of soldering tool can produce a professional job which will not cause any further trouble. Using an oversized soldering iron or gun, on the other hand, may damage the circuit board by causing the copper foil to let go. This will mean extra time and effort to try to repair the damage caused by overheating.

While it is difficult to make generalizations about tools and test equipment, the safest thing to say is to try to find out what is in use from other service technicians. Determine what they like and don't like about the equipment. Learn how to use different test equipment for different purposes so that you will be ready when new situations arise. Be familiar with parts and tool catalogues.

Unit 18

This unit is about cables and plugs. While those items are not an actual part of a cassette tape mechanism, they are just as important and they can be a source of some problems, some of which can be confusing.

Most portable cassette machines, especially those in the low to mid price range use two basic kinds of plugs for audio connections. The microphone of most portable machines contains an example of both kinds of plugs. The smaller of the two plugs is the switch plug. This is called a <u>subminiature</u> phone plug. It contains two connections. The body of the plug is one and the bead at the end is the other. The second plug on the microphone plug handle is known as a <u>miniature</u> phone plug. It contains two conductors also. The body of the plug is the ground conductor and the bead on the end is the center conductor for the shielded cable which carries the microphone signal. The jacks in which the miniature and subminiature plugs fit are similar except for size. Some miniature jacks have three terminals even though they have only two conductors. This third terminal is a switch terminal.

Such jacks are used in speaker circuits so the speaker will be shut off when an earphone is plugged in. Inside the jack is a little metal contact which normally rests against the curved center contact which touches the bead on the plug. The switch terminal is connected to this contact. When there is no plug, the center conductor contact touches the switch terminal contact. When an earphone is plugged into the jack, the center or hot contact is pushed away from the switch terminal conduct and the speaker is silenced. Power still flows to the earphone. Some recorders use a similar jack on the microphone audio connection. This type of plug disconnects the line or high level input when a microphone is plugged in.

On some machines, the jacks are all part of one panel so that a bad jack means replacement of the whole jack panel. Another kind of jack found on a few portables and a good many non-portable recorders is the standard quarter-inch phone jack. This jack accepts the large type plug found on some headsets. This jack is made exactly the same way as the miniature and subminiature jacks only it is larger. This one would be a good type to examine to see how these jacks work. The parts are all easy to see and fairly large.

When replacing one of these jacks, especially one of the switching jacks, be sure to check to make sure that the center conductor terminal is where you think it is. When no plug is in place, an ohm meter will show both the hot terminals connected together as they should be. When a plug is inserted, one of the two terminals will go out of circuit and not be connected to anything. This would be where the speaker lead would be soldered. The other terminal will remain connected to the bead or center conductor of the plug. This is where the output of the amplifier is connected. A third variation of the standard phone plug is the stereo phone plug. This type of plug looks very much like a standard quarter-inch phone plug. The only difference is that it has a break in the ground sleeve. If you look at such a plug, you will see the bead at the end, a little collar below that which is the same size as the body of the plug, and below that the body or ground conductor of the plug. If the handle sleeve of the plug is unscrewed, you will see the ground conductor, usually the longest of the three, and two other terminals corresponding to the right and left channel connections. A stereo headphone jack may have contacts for disconnecting the speakers just like a monophonic jack.

There is apparently no set standard to determine which of the two hot conductors goes to right channel and which goes to left channel. The best policy in repair would be to try to solder the wires back the same way they were originally.

A few jacks are specially made and have multiple contacts. While these might look confusing at first, they are no more than complex versions of the jacks which have already been discussed. These usually look quite different and are easy to spot. Instead of having the contacts around the mounting ring, they may be on a little terminal block with springy fingers extending to meet the plug. They may look a little like the relays and switches which use leaf spring contacts.

It is possible to buy all of the plugs and jacks mentioned here as replacements. With plugs, the problem is to find one which is sturdy enough to take the abuse which comes from normal use. Subminiature plugs are probably the biggest example of this problem. Their terminals are tiny and closely spaced. Sometimes it seems easier to spill solder from one terminal to the other than it does to solder the terminal correctly. Another problem is that the plastic insulator is easily melted by too much heat. For this reason, it is good to be as careful as possible and do the job right the first time.

Miniature plugs are almost as bad but not quite. Some are available with metal handle sleeves. These are very rugged but care must be taken to be sure no strands of the center conductor wire come in contact with the body of the handle which is at ground. These plugs usually have a plastic or paper ring which slips over the terminals of the plug, but it never seems to cover enough to keep an annoying short from occurring. The solution, be neat and careful. Be sparing with the solder used. All that is necessary is to get a good shiny solder joint which fuses the wire to the terminal. A big glob of solder will make it difficult or impossible to screw on the sleeve. It may be necessary to practice soldering such a plug several times.

The quarter-inch phone plugs are very easy to solder by comparison. Their terminals are large enough to take almost any size wire used for audio purposes. Many phone plugs and even a few of the miniature variety have small screws which, in some cases, can be used to hold the wire instead of solder. Usually, though, it is better to remove the screws and solder as would be done in a normal type solder connection. Some of the standard phone plugs can be purchased with metal handle sleeves. These are best where they might be stepped on or are dropped frequently. Plastic handles are strong, but they will smash under a person's weight.

On the cassette decks used for high fidelity purposes, another kind of plug is common. This is the phono jack and plug. These are the kind of plugs found on turntables, tuners, and amplifiers. They are also known in slang as RCA plugs. When buying a plug or jack, it is necessary, however, to ask for a phono plug or jack. Phono jacks and plugs are very simple. The plug has a center conductor which looks like the body or ground conductor of a miniature phone plug. Around this center pin is a bell-shaped cup which forms the ground connection. Some phono plugs have a sleeve which screws onto the body of the plug and others have no such sleeve. The center pin is hollow and will accept the center conductor of most shielded audio cable.

To do a good job of soldering one of these plugs takes a little practice. The idea is to heat the center conductor enough to let solder flow into the hollow pin and around the wire inside. Too much heat will melt the insulator and ruin the plug. Too little heat will create the illusion that the solder connection is good when it is not. The center pin will seem filled with solder and the wire may be tight. A little movement, however, will break the thin glaze of solder and the job will need to be done over. Also, if any solder flows down the outside of the center pin, it should be removed. Leaving it there may spring the contact in the jack so that it will not make good contact.

Replacement phono jacks come in several varieties. Some jacks have a nut which holds them in place like the nut on a phone jack or volume control. Others have a nut which is screwed down before the wire is soldered. It is a lower profile jack since the nut is behind the panel instead of in front. It is also hard to tighten if it works loose after the wires have been soldered. Still other phono jacks are mounted on plastic rings or ears which make it possible to mount the jack so that neither the center conductor nor the ground are in electrical contact with the mounting panel.

It is possible to buy little plastic panel with several jacks mounted in a row. The only thing to keep in mind when replacing a phono jack is to replace it with one which is electrically the same. If the original jack was grounded to the metal chassis panel, the new one should be also. If the jack was insulated from the panel, the new one should be also. Hum and noise can result from changing the ground setup on some type of input jacks. Some outputs must be above chassis ground in order to work properly.

Another kind of plug found on professional and some high quality machines is the XL3. This type plug is also called a CANNON plug. This is one of those trade names which has become slang for that type of plug. Such plugs are found on microphone inputs and are used for what are known as <u>balanced lines</u>. A cable containing a balanced line may look, at first glance, like a stereo cable. Afterall, there is a shield and two wires. What this is, however, is a method to get rid of as much hum and noise pickup as possible. Rather than having the shield act as the return lead for the audio, a second wire serves as the return. Both wires are shielded. The idea is to have both wires free from any connection to ground, or if there is a connection, it should have the same resistance for both wires. This means that static received on one of the wires will be canceled out by the static received on the other line. Many balanced lines end in transformers. Neither end of the transformer winding is grounded so the two wires in the cable are both free from any connection to ground. If one wire becomes connected to ground, the other wire will still be able to receive noise from the air. The noise will no longer be canceled by the other wire, and it will be heard.

One good way to understand how a balanced line system works is to find a recorder or amplifier with a balanced line input. If it is possible to touch the two hot leads, at the microphone input, do so and listen to the hum in the monitor or amplifier output. If you touch both balanced line leads at the same time, the noise will be much softer than if only one or the other lead is touched. Touching the ground lead will not cause any noise. In fact, this is a good way to tell which pin is ground if you don't want to look inside and see.

The type of plug which is being described here can be found on expensive studio type microphones and on the microphones used in public address systems. There is no standardization on the use of male and female plugs and jacks. Some equipment uses a male input and others may use a female input. The same is true with balanced outputs. The plugs and jacks are about the size of a person's thumb. They are bell shaped when mounted on a cable. If the device is a plug, the bell-shaped housing contains three pins arranged with a space between two of them. The matching jack, if chassis mounted, has a latch button off to one side. When the plug is turned to fit, and pressed into place, it clicks firmly. The latch matches a small hole in the bell-shaped housing of the plug. The button must be pressed to release the plug. This means that the plug cannot fall out. If the situation is reversed and the plug is mounted on the chassis with the jack mounted on the line, the latch is on the side of the jack. When making audio cable using balanced lines, it is necessary to keep the wires straight. The ground shield is obvious because of its appearance. The other two wires, while they must be above ground, must also be kept standard as far as color coding. Most balanced line cable has two distinct colors of wire. If, for example, the red wire goes to pin two on the audio connector at one end of the cable, it should go to pin two at the other end. Actually, as long as the ground is in place on the right pin, the other two wires can be reversed, but this creates problems at times, and should be avoided.

Another kind of plug and jack found in some high fidelity equipment is the DIN connector. This is a round plug containing several pins. It looks like the base of a small radio or television tube. While this kind of plug is not popular in the United States, it is used on some European equipment. The cables leading to such plugs may contain a multitude of wires. They are used for connecting equipment together where several things must be done by the cable. Instead of having several separate cables, the DIN connectors allow several cables to be joined into one bundle. DIN connectors get their name from the German organization which sets standards for recording equipment in Europe (11).

As you can see, there are many kinds of plugs and jacks in use in recording equipment today. Some companies make adapters which will convert one type of plug into another. These devices look like a jack on one end and a plug on the other. They can be purchased from high fidelity supply companies and the makers of plugs and jacks. Most large high fidelity stores stock the more common types of plug adapters.

Let us look at some of the problems encountered with jacks. Jacks receive a beating even when they are carefully used. The contacts inside them are made of springy metal, but they can only bend so many times before they break or loose their tension. Sometimes, it is possible to save a headphone jack by bending the contact gently back so that it presses more firmly against the plug or switch contact. Sometimes, the switch contact can be bent so that it contacts the spring center conductor more firmly. Many times, however, the spring contacts will bend back the way they were before in time and the whole process will need to be repeated. A new jack is the best remedy for this problem if it is caused by wear.

The same kinds of problems can result from wear to phone jacks and their plugs. Sometimes the bell-shaped ground connection will become spread out and not make good contact. This can be corrected by slightly squeezing the body of the plug with pliers.

It should be easy to find examples of all the plugs mentioned here. The only kind which may be a little difficult to locate is probably the DIN connector. Balanced audio plugs may also be a little harder to find, but the phone and phono connectors should be easy to find.

Unit 19

This section is about batteries. For the most part, equipment such as portable cassette tape machines is designed to use a certain type of battery and that is all that will fit into the battery compartment. The question of what kind of battery to use, then, presents no real problem. Nowadays, there are several different types of batteries available. Some are rechargeable and others provide more current. If the repairer of cassette machines understands the similarities and differences between the different types of batteries, the task of suggesting the appropriate battery for the job to be done will be much easier.

Many cassette machines use several flashlight cells to generate the power for portable operation. The standard flashlight cell produces 1.5 volts. It is the most common form of dry cell in use. It is also the cheapest. It is known as the carbon-zinc battery and has been in use for many years (12). Carbon-zinc cells are enclosed in steel shells to strengthen them and help keep their chemicals from leaking out as readily. The battery itself is a zinc can filled with a paste made of amonium chloride and graphite with other chemicals added in various amounts to strengthen the electrical conductivity of the solution (12). The zinc case of the battery forms the negative terminal. The lid of the battery, the part with the tip, is attached to a carbon center rod which extends the length of the cell, but is insulated electrically from the zinc case. When the electric current flows from the battery, the zinc is changed into zinc compounds and these gradually build up around the carbon rod or positive terminal.

Carbon-zinc cells are not considered rechargeable. It is, however, possible to partly recharge one which has been discharged quickly. This is, however, a risky process since some batteries may overheat and burst (12). The technique involves running a current of 150 ma through the cells for four hours. The batteries should set for six hours to allow the voltage to stabilize. Since carbon-zinc cells are relatively cheap and the mess caused by a burst cell can cause expensive damage, it is probably better to simply replace the dead cells.

Another kind of dry cell which is becoming more common is the alkaline battery. This battery is similar in construction to the carbon-zinc battery except that an alkaline chemical is used for the paste or electrolite solution. A few of the brands of alkaline batteries are said to be rechargeable and these will say so on the labels. Generally, though, alkaline cells are not rechargeable.

The alkaline battery is superior to the carbon-zinc battery in that it can supply more amperage at any given time. It also keeps a steadier voltage output during its lifetime (12). The output voltage of an alkaline cell is 1.5 volts just like a carbon-zinc battery. The alkaline batteries are available in all of the sizes in which carbon-zinc cells can be found. They are directly replaceable and many times cause equipment to operate better due to the more constant output. They are, however, more expensive.

The commonest kind of rechargeable battery by far is the nickle-cadmium cell or nicad as it is informally known. Nicads have many advantages such as high current capability, steady output voltage during a charge life cycle, and they are completely rechargeable for as many as hundreds of times. They do have two large disadvantages. One is their cost which may be several times that of even alkaline cells. The other is their output voltage which is only 1.25 volts (12). A cassette machine with a battery supply using eight carbon-zinc cells, 12 volts, would only receive 9 volts. This would probably not allow the motor regulation to be good and the audio might be weak or distorted. The recorder would act as if it were operating on slightly weak batteries even when fully charged.

Nicad cells can store almost as much charge per weight as an automobile battery. One D nicad cell is rated at 80 amp/hr with a load of 50 ma (12). The problem which is sometimes found in battery systems is that they cannot deliver their actual rated current at full load because they may overheat or chemical reactions in the battery may not be able to take place fast enough to satisfy the demand. The battery will appear to go dead quickly and then will appear to recover after being allowed to stand idle for a while. Nicads can deliver a lot of current, but may heat. Some large nicads are used to start aircraft engines. The nickle-cadmium cells available for portable equipment are able to handle the current demands of anything which is designed to operate on carbon-zinc cells. Remember that nicads contain quite a bit more energy than carbon-zinc cells and short circuits can be potentially more disastrous under these conditions than they would be with conventional batteries. If the equipment in question can operate under the reduced voltage of the nicad cells, there should be no problem.

Nickle-cadmium cells contain a plate coated with nickle salts and another coated with cadmium salts. These plates are separated by an electolite solution which is alkaline. As the battery discharges, the nickle and cadmium salts turn into the metals nickle and cadmium. When the battery is recharged, the process is reversed and the metals are turned back to their respective salts. Some nicads are stored and shipped in a discharged condition and must be fully charged to use.

Chargers for these batteries can be purchased from most electronics companies. They simply run a current through the cells which produces the chemical changes talked about. The current should not be so high that the batteries overheat and are damaged or exploded. The charger, therefore, should be matched with the size of battery which it will be charging. Simply read all of the data on the unit before using or purchasing. According to all information, nicads are not hurt by leaving them on a charger for long periods of time. They simply use what current they need and then stop drawing anything but a tiny amount of current.

Some equipment already comes with rechargeable batteries and a built-in charger. Most devices of this type can be left on charge all the time. It is not unusual for the batteries to get slightly warm. While it does not hurt them to be left on charge, it probably may help to extend the life of the cells if they are not left on charge if the tape recorder or other device in question is not to be used for a long period of time such as several weeks. Nicad batteries are chemical devices and chemical changes take place faster in heated areas than in cooler places. Nicads which are in good condition can hold a charge for months at a time.

Nickle-cadmium batteries will probably become more common as time goes on this will make it easier to find replacements for dead battery packs or individual cells. There are a few measures which some people try with varying success to rejuvenate a nicad cell which refuses to hold a charge. One technique is to take a very large filter capacitor such as a 20,000 mfd and discharge it observing the correct polarity into the nicad cell. This is supposed to burn out small amounts of debris which may collect in the cell and short it out. The cell will, sometimes, be able to recharge again after two or three shots with the capacitor.

In conclusion, the batteries used in portable recorders and, for that matter, other appliances are generally three basic kinds. Carbon-zinc is the least expensive and most common. Alkaline cells produce the same voltage as carbon-zinc cells but at higher current and for a longer time. Nickle-cadmium cells are the highest current cells but produce only 1.25 volts each compared with the 1.5 volts found in the other types. Nicads are also rechargeable many times. They are the most expensive of the commonly available batteries.

Unit 20

This unit is about locating problems without test equipment. There are times when servicing of a piece of equipment is required when the equipment cannot be brought into the shop. Other times, a piece of test equipment may break just when it is needed. While there is no really good substitute for a volt meter or oscilloscope, there are some quick things which can be tried to find out basic facts about the operation of a tape recorder. Let's start with the power supply. In portable cassette machines, the power supply will be either a power adapter or a set of batteries. With batteries, there is the obvious possibility that a battery has gone dead or run down. This can be checked with a volt meter when the machine is in operation. There is another good way to see whether a cassette machine is getting full power. This involves playing a pre-recorded cassette containing music or speech. Turn the volume as high as you can and see whether the motor keeps a steady pace. If it runs correctly during quiet spots and drags when the sound is loud, there may be power supply problems. If there is not enough power to go around, the motor will not be able to turn fast enough.

The important thing, in a problem like this, is to take nothing for granted. Make sure all the batteries are good by checking them under a load. If the machine uses individual flashlight batteries, each battery can be used to power a flashlight bulb while it is being checked. If the batteries are good, put them back in their holders and play the tape again. Turn and wiggle the batteries to make sure the problem is not simply a bad connection with the battery holder. It it is, it should show up very quickly as a change in the operation of the machine each time a battery is moved. If the battery holder is not a problem, see how the machine works on its AC power pack. Remember that most all cassette machines have some kind of speed regulator on the motor and changes in sound level should not cause changes in motor speed under normal conditions. If the same thing happens with the power adapter attached, check every switch that the DC power must pass through in order to run the machine. Sometimes switch contacts become putted and no longer make good contact. If the materials are handy, short across each switch to momentarily take it out of the circuit and see how that effects the problem.

One thing which can help, if all else fails, is to find out whether the problem is characteristic of that particular make of machine. Usually, in a case of low power, the problem is partially electrical and partially mechanical. Another thing to look for is sluggish starting of the machine during any of its functions. Most machines, if they are receiving the proper amount of power, will start quickly. A machine with low power may take a second or two to reach the proper speed if it can do even that.

There needs to be a good way to tell quickly whether a tape recorder is running at the correct speed. One way to do this is to compare the recorder in question with one which is known to be accurate. There is a frequency standard which is almost universal and which can be found, sometimes whether we like it or not, in almost any AC powered equipment. That is 60 hz or 120 hz hum. Tape recorders which get their power from the AC lines, usually have a small amount of hum in their audio. One way to make a very rough guess as to the speed is to take a commercially recorded tape which was produced by a reputable recording company. This tape can be either music or voice. A good possibility is to find a tape of a live music or lecture performance. Such tapes may have a little hum which can be heard as part of the background noise. Since recording companies are interested in producing as good a product as possible, there may not be very much hum, but what hum there is will probably be very close to the correct frequency. This means that if the speed is correct on the recorder in question, the hum will sound like a 60 hz hum. One way to compare the hum on the tape with the hum of equipment is to find a quiet passage on the tape and turn up the volume until the background hum matches the residual hum of the amplifier. Be sure that the hum you are hearing is not just residual amplifier hum. The sound to be listend for is a sound similar to that heard when two musical instruments are being tuned. It may take some practice to accustom one's ears to what should be heard. When a recorder is found which is known to be accurate as possible, a test tape can be made by using a tuning fork or something else which can give a very accurate pitch such as a pitch pipe. This will make it possible to make a quick check of any recorder to see whether its speed is close. Most recorders will be slightly off, but the difference should not be great enough to produce a discordant sound when the two pitches are compared. Remember, this method should be used as a last resort and is only an approximate way to measure the speed of a tape recorder.

It is also possible to make a fairly reliable test tape for wow and flutter. This can be the same tape used for speed checks. The only thing that is necessary is to make sure that the recorder being used to make the test tape is as free from wow and flutter as possible. Throughly clean the capstand and pinch roller and listen to the note played back to see whether any wow or flutter can be heard. Do this a couple of times on the same machine to be sure that there is no flutter. If the tape is played on another machine and a distinct quaver or slow regular changes in speed are heard, it is pretty certain that that machine has a speed problem.

Along with all of the good test equipment in the service shop, it is not a bad idea to have an FM tuner. The main qualification should be that this tuner be able to receive a good FM broadcast signal with no distortion. If the tuner is stereo, that is nice, but it is not totally necessary. Two things can be done with a tuner which are difficult to do with more standard test equipment. The tuner will supply an almost continuous amount of audio programming of the type usually recorded on cassette tapes. It is possible to receive voice, music, and related sounds. Another thing which can be received with a tuner is the noise between stations. This is the loud hissing sound which has no particular pitch or rhythm to it.

It is a good idea, when using FM tuner hiss to disconnect the antenna if possible and tune the unit to a spot where there is no station likely to create even a weak signal. An oscilloscope will reveal that the noise from the tuner is made up of a large number of different pitches. In fact, the oscilloscope will never be able to show anything but a pattern of wavy lines like TV snow. This is a good way to supply a cassette recorder with all the audio frequencies at once and do it cheaply. If the tuner is stereo, be sure that it is switched to mono so that the signals from the stereo receiving section will not cause any change in the noise.

As was pointed out earlier, the high frequencies of sound are affected most by problems with head alignment and head condition. When recording FM tuner hiss, see how closely the played back hiss sounds like the actual tuner hiss. If the tuner hiss can be heard through the monitor, this makes for a very good comparison. The tuner hiss will usually sound crisper and steadier than the recording of the sound on tape. If the recorded sound is rough with many changes in level, there may be a problem with head wear. Be sure that the tape itself is not worn out. It might be good to try several good quality cassettes on the same machine before making judgment on the heads. If the heads are out of alignment, the hiss will sound muffled and bassy. There may even be swishy quality like sounds of ocean surf in which it sounds good one second, and bassy the next.

Try turning the head alignment screws to see whether the problem goes away. If this makes it better, use a test tape to do the job properly.

It is probably better for the beginner to stick to established methods of testing and trouble-shooting, at first, but as time goes on, it should be possible to use some of these improvised techniques to make, at least, the first observations on a machine. Since cassette recorders were not designed to record pure tones, it is good to use a signal which is closest to the kind of signal which the recorder will usually be handling. The FM tuner will be good for this purpose. The best service technicians should be able to get the best information out of all the techniques they use. Some improvised techniques can give information which might only be gotten with the most elaborate expensive test equipment. As long as the repairer knows the limits of what can be done with a certain service technique, there is nothing wrong with using it.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This thesis is based on the belief that gaps exist in the bank of readily available information concerning the repair of certain types of commonly available electrical and mechanical equipment.

The main area of concentration, here, is that of information about repairing cassette tape recorders.

The review of literature relating to the repair of electronic and electro-mechanical equipment shows that there is no shortage of books on basic electronics or, for that matter, on the repair of radios and television sets. When it comes to the subject of tape recorders or even phonographs, the trail begans to fade and the repair technician must take much more time to find the desired information.

It was also believed that this situation caused many service technicians to refuse to do repairs which would have been in their capabilities had they known where to start. Other technicians might do poorer quality work and take longer at it than would be necessary.

This thesis, then, attempts to show where the informational gaps exist, why such gaps need to be filled, and what such material should cover in the different subject areas.

Chapter Three contains a sample textbook using a narrative style which gives basic information on what the repair technician or student learning the repair business should expect to find.

Finally, the suggestion is made that gaps exist in other areas of technical study.

Conclusions

This is the type of material which may be found more and more as time goes on. It is hoped that it can be used in a setting where it will supplement actual experience to produce technicians with a grasp of both the practical and theoretical aspects of service work. It is believed that good repair technicians must have both aspects of repair which are equally important.

Recommendations

Several areas lend themselves for further study. There always needs to be a concerted effort to locate those areas of technical education which have a lack of traing material. It is also necessary to know why there is no information if such an area is discovered. If a need is established, material should be created which will best suit the purpose.

To do this, a study should be made as to what kind of material is best. This need not be a formal study, but some thought should be given to this question and a formal study done if necessary.

In the specific area of cassette tape recorder repair, it might be good to determine whehter any type of audio-visual hardware could be developed to speed up the learning process, particularly when rather complex systems are being discussed such as servo mechanisms.

In most technical areas, the simple informational approach seems to be the best. There would probably not be much need to study whether some other approach would work for conveying information since the material lends itself nicely to explanation and/or demonstration.

An area which has been studied before, but could still use more research would be that of determining what qualities make good technicians. Also work should be done on the informational content of the explanations to determine how much abstract theory is needed to understand a principle.

Finally, it is safe to say that what has been done here is only an example of technical educational material and much more probably needs to be written about many areas. Probably the most important thing of all will be for researchers and educators to keep looking for possible areas which need educational material along this general pattern.

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