BIRDS BEES AND CAPACITORS

EXPLAINED BY G.V. PECK

ILLUSTRATED BY BOB KEISTER

MALLORY

MALLORY CAPACITOR COMPANY

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INTRODUCTION

This booklet will acquaint you with the construction and uses of an important electrical component—the capacitor.

The story uses a minimum of technical language in explaining electrical phenomena and the function of the capacitor in circuitry.

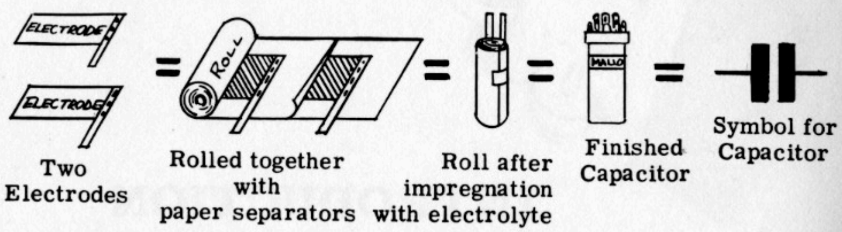
Birds, Bees and Capacitors was originally published in 1954—since then it has been reprinted seven times. We hope it continues its popularity and that you will enjoy this revised edition.

■ CHAPTER 1

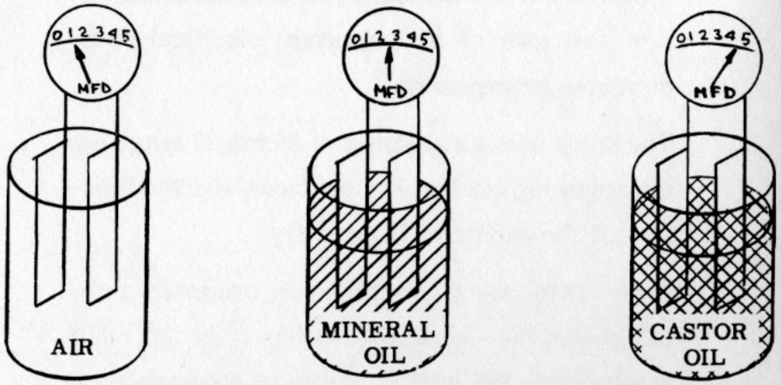
WHAT IS A CAPACITOR?

(Editors Note—The first line tells you—but we recommend at least the first four paragraphs. If you like this kind of stuff, read the whole chapter—but don't let paragraph B throw you.)

Reduced to its simplest terms—a capacitor is a device for temporarily storing electrical energy. It consists of two conducting (generally metallic) surfaces, called the "electrodes," placed close together but not touching each other.

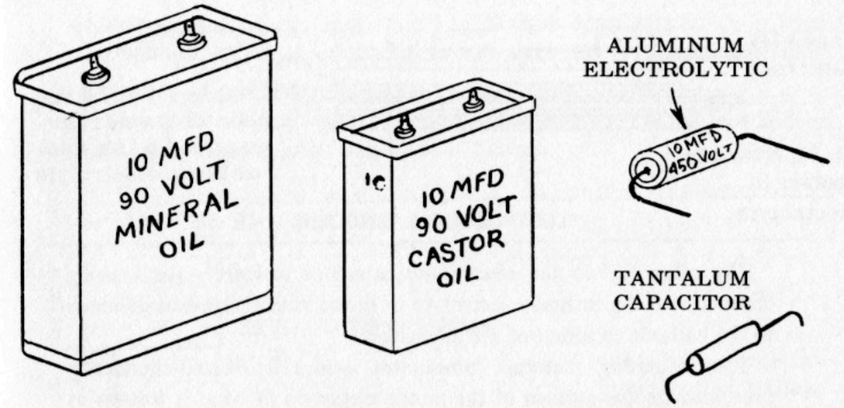


The "capacity" of a capacitor depends on the area of the electrodes and how close they are to each other. Also, the material between them affects the capacity. For instance—impregnating a dry paper capacitor with mineral oil would raise its capacity 2.7 times. Impregnating with castor oil would raise the capacity 4.6 times.



SHOWING CAPACITY CHANGE WITH DIFFERENT MATERIAL BETWEEN THE ELECTRODES

Dry electrolytic capacitors have about 100 times (at 90V this may be higher, perhaps 100X) the capacity of paper dielectric capacitors. This is due to the electrodes being so close together as well as to the nature of the oxide film between them.

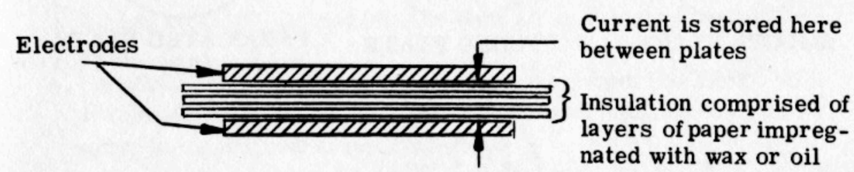


RELATIVE SIZE OF MINERAL OIL, CASTOR OIL AND ELECTROLYTIC CAPACITORS

The basic measuring unit of capacity is the Farad, named after Michael Faraday, an early scientist. The Farad, however, is too large a unit for practical use, therefore, micro-farad (one millionth of a farad) is used. It is abbreviated to MFD and is seldom spelled out in practical use. Very small values are designated by micro-micro farad or MMF. Example: .0005 MFD = 500 MMF.

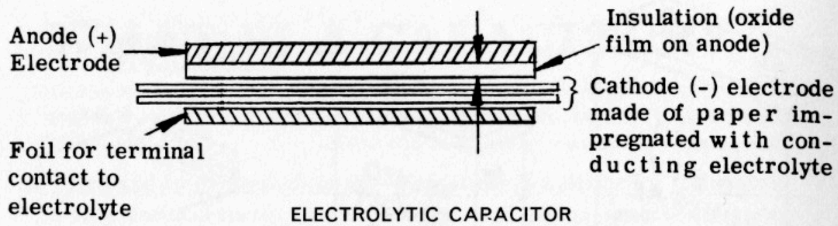
There are several types of capacitors:

A. Paper or plastic film capacitors are usually rated from .0001 Mfd. to 50 Mfd. and at voltages from 50 to 10,000 DC and from 60 to 4400 AC. These are usually impregnated in various types of wax, oil or synthetic oil, depending on the application.



PAPER CAPACITOR

B. Aluminum electrolytics use aluminum oxide as the insulating material between the electrodes which are of different materials in this case. The anode (+) electrode is aluminum. The cathode (−) electrode is made of paper impregnated with a conducting electrolyte.



ELECTROLYTIC CAPACITOR

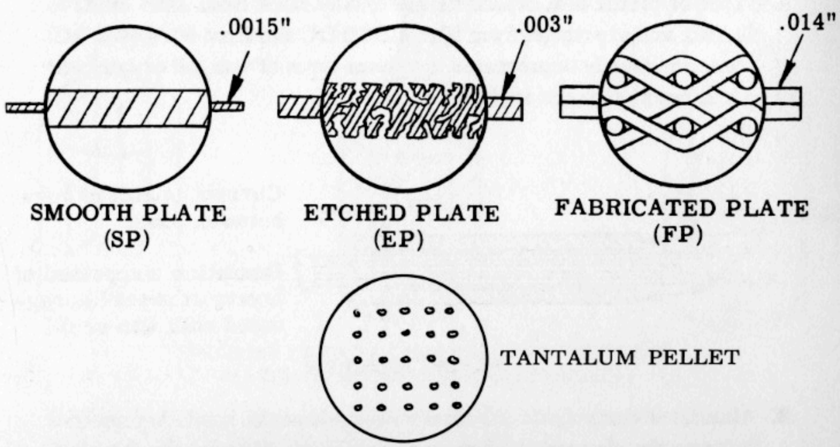
The other foil in the electrolytic capacitor is merely for making contact with the cathode electrolyte so that a connection can be made to the cathode terminal of the capacitor.

The insulating material (aluminum oxide) is electro-chemically produced on the surface of the anode electrode in what is known as a "forming bath" in the forming bath department.

C. Tantalum electrolytics use tantalum oxide as the insulating material between the tantalum anode and the electrolyte which is the cathode.

The case of the tantalum capacitor is negative and lined with pure silver to eliminate the possibility of cathode formation.

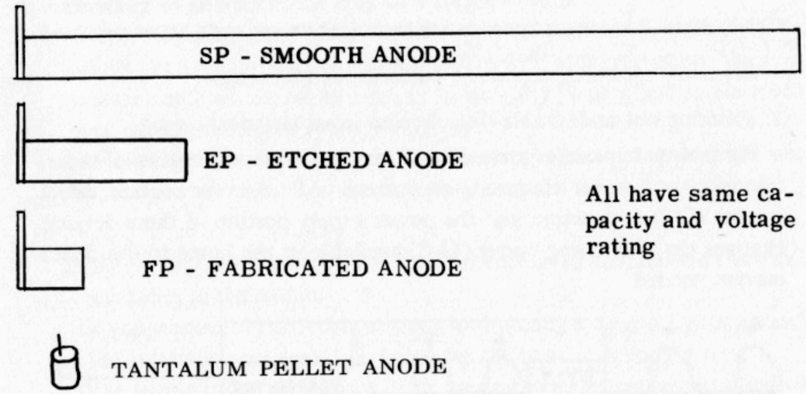
Paper capacitors always use "smooth" foil or "plate" as it is sometimes called. Aluminum electrolytics generally use etched (EP) or fabricated (FP) plate. These terms denote that their surface area (therefore their capacity value) has been increased many times that of smooth plate (SP) by a roughening process. Tantalum capacitors use sintered powder pellets or foil for anodes and also provide high capacity values.



EDGEWISE VIEW OF VARIOUS ANODES UNDER MICROSCOPE

Etching increases the area from 5 to 20 times depending on the voltage rating. Spraying molten aluminum on gauze (FP) increases the area approximately 15 times regardless of the voltage rating.

Sintering (welding) minute particles of tantalum powder into a porous pellet increases the area from 20 to 100 times.



RELATIVE SIZE OF SP, EP, FP AND TANTALUM ANODES

Paper capacitors can be used continuously on either AC or DC circuits and are not polarized (do not have a plus and a minus terminal). Electrolytics may be used on DC continuously but only for brief periods on AC. Except when designed for brief AC use, they are polarized (have a plus and minus terminal) and would be damaged if the voltage were reversed.

The words "Capacitor" and "Condenser" have the same meaning in this industry. Since there are such things as "steam condensers" the term capacitor, which has no alternate meaning, has been adopted for our product.

Mallory oil paper capacitors cover a range from .5 to 100 Mfd. at voltages up to 1000 DC and 660 AC. These are made in the Crawfordsville plant.

Mallory Aluminum electrolytic capacitors range from 5 to 200,000 Mfd. at voltages up to 500 DC and 440 AC. Improved high ratio high purity etched foil is now used almost exclusively.

The Mallory developed type FP fabricated plate, anode which set the pace for high quality for 20 years, has finally been matched by newly developed high purity foil and is no longer used. Aluminum electrolytic capacitors are made in the Indianapolis and Huntsville plants.

Mallory tantalum foil and pellet capacitors range from .33 to 2250 Mfd. at voltages up to 630 DC. These are made in the Greencastle plant.

■ CHAPTER 2

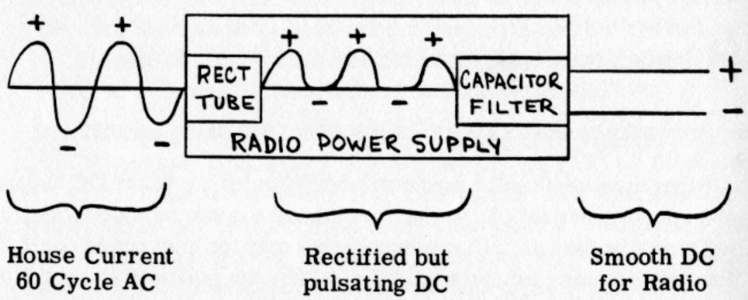
WHAT A CAPACITOR DOES

(Editors Note—Someone is bound to ask you sometime—so you'd better read this!)

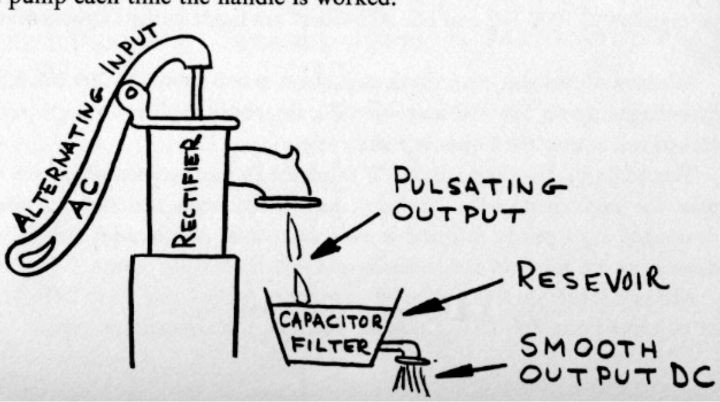
Generally speaking, capacitors perform the following—

1. Filtering out undesirable disturbances in an electrical circuit.

Electrolytic capacitors are used as filters in the power supplies of radio, television and other electronic equipment. All of them require direct current (DC) to function and the power supply portion of these devices, changes the alternating current (AC) available in the home to the direct current needed.



Briefly this is accomplished by first rectifying (changing the AC to DC) by using a rectifier of the tube or semi-conductor type. The resulting DC is still unusable since it is pulsating and needs further smoothing or "filtering." At this stage it can be compared to the water spurting from a pump each time the handle is worked.



When added to the circuit, the capacitor in this case fills up with electricity with each impulse from the rectifier and spills over gradually, providing an even flow of direct current as needed. This would be equivalent to pumping water into a large tank that had a small faucet causing the water to flow from the tank in a steady stream.

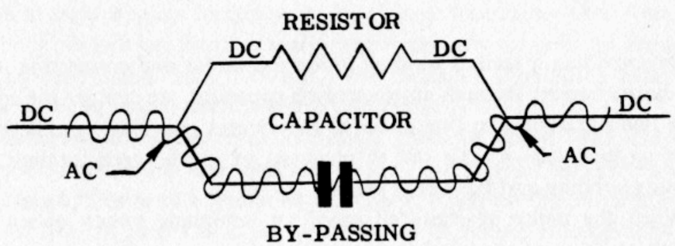
Paper capacitors are used in filtering electrical noises produced by various electrical appliances which interfere with radio reception. Vacuum cleaners, food mixers, oil burners, or in fact, any place where an electrical spark occurs, can cause radio interference.

Here, capacitors installed on the offending device, trap or filter out the portion that radiates in the frequency range of the radio receiver.

2. By-passing or providing a short cut for current to flow around electrical obstacles in the circuit.

If you wanted to cut across an open lot by using a diagonal path instead of the sidewalk, you would be *bypassing* the regular or longer way.

The wiring inside any device using *vacuum tubes* or *transistors* is called an "electronic" circuit. All such circuits have both *direct* current (to make the tubes operate) and alternating current (representing the speech, music or picture frequencies) flowing simultaneously over the same set of wires inside the device.



It is often desirable to arrange for the AC to jump over or *bypass* some of the DC network of resistors and other wiring. This is called *bypassing* and helps preserve the weak radio impulses that otherwise might be lost in the maze of DC wires. Both paper and electrolytic capacitor are used for *bypassing*.

3. Spark-killing

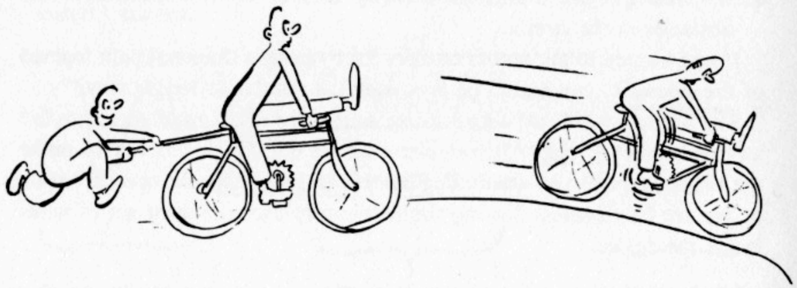
Whenever an electrical contact makes or breaks the flow of current, a spark or small arc occurs. This arcing wears down the contact points and eventually they stick together or wear out.

If a capacitor is connected across the points, it absorbs this electrical energy, thereby reducing or eliminating the arcing.

There are many uses for such an arrangement—Auto distributor capacitors, Thermostat capacitors and any other case where electrical contacts are used.

4. AC Motor Starting and Running

Electric motors require what is known as two-phase current for starting. The single-phase current supplied to homes can be likened to a bicycle with one pedal. When the pedal is in the down position some other force is necessary to start the bicycle. However, once the bicycle gains speed, you can manage to keep it going with the one pedal by proper timing.



By providing a second winding inside the motor and connecting it to the house current through an electrolytic capacitor, we can get the effect of a two-pedal bicycle. One phase of the current goes through the main winding and one—a little out of phase so to speak—goes through the starting winding and the motor starts.

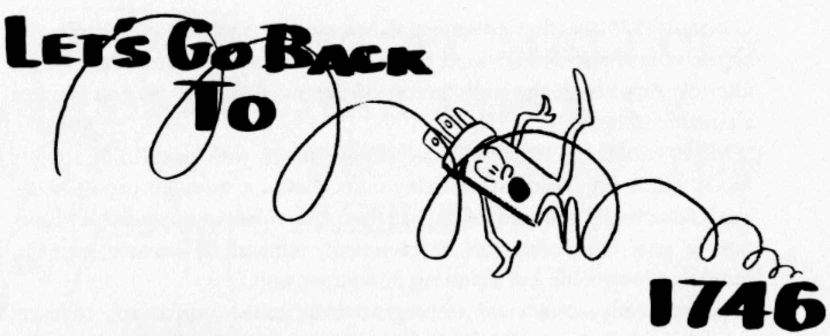
When the motor reaches full speed an automatic switch opens the circuit to the capacitor and the motor continues now as a single-phase device.

Motor-run applications are similar to the motor-start type but are designed for continuous operation. For this reason oil paper capacitors must be used. (Remember?—Electrolytics cannot be used continuously on AC.)

The air-conditioning industry has provided a very sizeable market for both paper and electrolytic capacitors.

There are many other uses for capacitors such as power factor correction, timing capacitors, welding, etc.; but the foregoing are typical of the larger areas of interest.

■ **CHAPTER 3**



A LITTLE CAPACITOR HISTORY

(Editors note—If you'll wade through this chapter, you'll know a lot more about 'em)

The first capacitor was in the form of a glass bottle coated with copper foil inside and out. These foils were cut back from the top to keep them from shorting together. It was called a "Leyden Jar" and was invented in 1746 by a Professor Cuneus at the University of Leyden, Holland.

Leyden jars were used commercially for many years—a large part of them in early wireless transmitters. An average transmitter used from ten to thirty of these jars, each measuring approximately six inches in diameter by eighteen inches high. Obviously the capacitor installation generally took up more space than the entire transmitter.

The first transmitting mica capacitors appeared about 1912, creating a drastic reduction in size compared to the Leyden jars. One mica capacitor, about the size of a pound box of candy, could do the job of a room full of Leyden jars. The same type of mica capacitor, considerably improved through the intervening years, is still widely used on high-voltage applications requiring relatively small capacity values, say from .00005 mfd. to .01 mfd. Larger values are seldom used due to price consideration, the more recently perfected high voltage oil paper capacitors being considerably cheaper.

Meanwhile, the advent of the telephone brought forth wax impregnated paper capacitors, later widely used in the radio field as filter and bypass units. Originally most of these capacitors were made by the telephone companies for their own use. Capacitor manufacturers, as we know them today, did not exist and the relatively small demand for other than telephone use was supplied by capacitors imported from Germany.

About 1924 the first commercial battery "eliminators" for radio use appeared and greatly increased the demand for paper capacitors used for filtering. As a result, the manufacture of paper and mica capacitors became a sizeable industry.

Paper capacitors were originally impregnated with paraffin or similar waxes which produced rather bulky units. Later, a wax known as "Halowax" (essentially chlorinated naphthalene) provided an appreciable reduction in size. Paralleling this development, mineral oil became popular, providing longer life but resulting in a larger unit.

Subsequently, castor oil impregnated capacitors appeared, effecting a reduction of about one-third in the size of mineral oil capacitors and approximating halowax units. However, this smaller size did not last as long nor stand high temperature as well as mineral oil capacitors.

The first electrolytic capacitors for radio receivers appeared in the early 1920's further reducing capacitor size. These were of the "wet" polarized type, limited to vertical mounting only and developed by Mershon whose patents were later purchased by Magnavox.

The "dry" electrolytic capacitor, pioneered by Mallory in 1928 was the next big step in the electrolytic type and is covered in detail in Chapter IV.

Synthetic oil capacitors like Mallory Mallotrol A types provide sizes comparable to the castor oil type or smaller but with quality approximating the mineral oil type.

High temperature tantalum capacitors were first made by Mallory in 1941.

■ CHAPTER 4

WHAT MALLORY HAS DONE IN THE CAPACITOR FIELD . . .

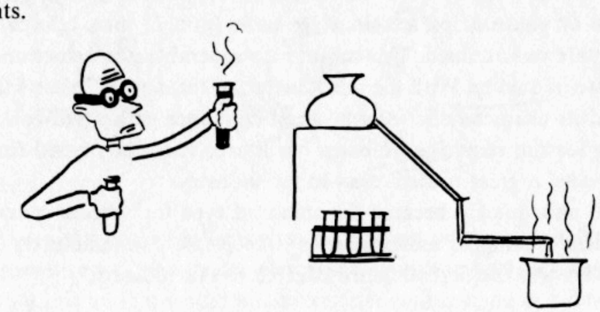
(Editors note—This is a long one—but it can't be told very well with less words)

MALLORY CONTRIBUTIONS

In 1926 Samuel Ruben, who had previously licensed the Mallory Company under his magnesium copper sulphide rectifier patents, invented the dry electrolytic capacitor.

Up to this time, the development of radio "A" battery eliminators had been retarded due to the lack of a small high-capacity low-voltage capacitor. The Mallory Company and the Grigsby Grunow Hinds Company started the production of dry electrolytic capacitors of this type and the first successful "A" battery eliminators soon followed.

Mallory then undertook an intensive development of the dry electrolytic capacitor and acquired exclusive rights under the dominating Ruben patents.



By 1929 Mallory was producing high-voltage dry electrolytics. Shortly thereafter, they had been accepted by the entire radio industry.

The dry electrolytic capacitor, with its tremendous size advantage over all other capacitors, represents one of the outstanding contributions to the radio and electrical field. It has displaced "wet" electrolytics and is universally used, not only in radio equipment, but for such industrial applications as motor starting and a variety of electronic devices.

The advantages of this development were quickly realized by other component manufacturers who applied for licenses under the Mallory controlled patents and several licenses were granted.

For several years units made with smooth aluminum foil and gauze separators became general construction. They were furnished in cardboard cartons and tubes, as well as round and rectangular metal cans. Many variations were in evidence in shape, mounting and terminal arrangements.

AC electrolytics for starting motors were also developed and Mallory soon became well known in this field. The motor industry has benefited greatly due to the Mallory contributions covering this application.

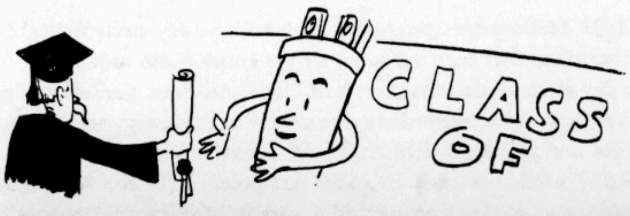
Meanwhile, new developments, in which Mallory played an important part, resulted in etched plate (EP). This brought another drastic size reduction. (Etching the anode foil or plate increases its surface area and therefore its capacity).

The first etched plate (EP) units produced gave approximately 2.75 times the capacity obtainable with smooth plate (SP) at 450 volts.

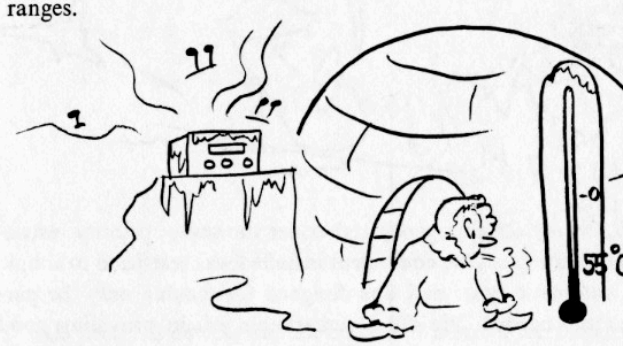
Meanwhile Mallory made many additional contributions extending the life of our capacitors and widening their field of application. Surge-proof separators, further size reductions, lower RF impedance, reduced coupling characteristics, etc., were of importance in this regard. These technical terms cover ideas Mallory put into production that helped make the small AC-DC radio possible and lowered the cost of radio sets in general.

In 1937 Mallory perfected and marketed the now famous FP capacitor. Through the use of anode plate fabricated in our plant by spraying molten aluminum on gauze strips, a ratio of ten times (now 15 times) the capacity of plain plate was attained. This meant a considerable size reduction, with no decrease in quality. With the introduction of this new FP plate Mallory developed its characteristic external bead container with a self-contained mounting feature requiring no extra hardware. These combined features have provided a great contribution to the industry.

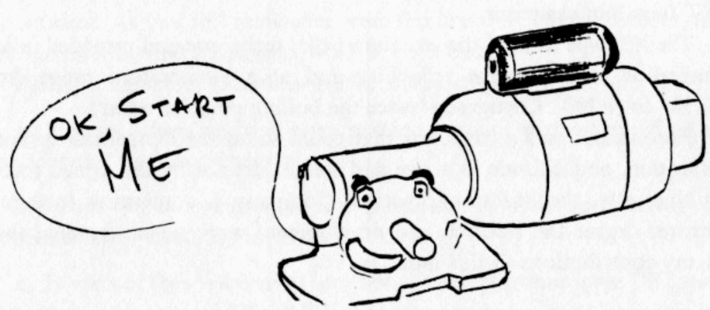
The FP unit quickly became the standard type for vertical mounting, being officially adopted as standard by the Radio Manufacturers Association. This was the first standard effected in this industry.



Mallory perfected a manufacturing technique that made possible the use of electrolytic capacitors at sub-zero temperatures. This was a great contribution to the war effort, enabling our armed forces to save considerable weight in equipment required to operate over wide temperature ranges.

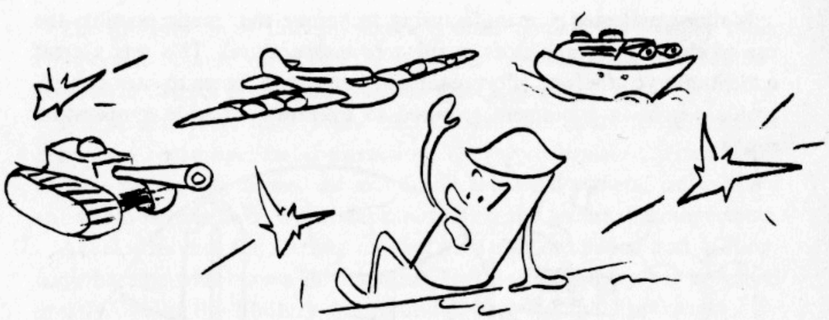


Mallory perfected a standard plastic case AC electrolytic for motor starting. The plastic case did away with the outer insulating cardboard tube formerly used over the original aluminum cans and a cause of frequent field trouble due to moisture absorption.



During the years Mallory was specializing on dry electrolytics, many customers urged us to enter the paper capacitor field. However, it was felt that this market would be unattractive unless some new development, providing either lower cost or substantial improvement, could be accomplished.

During the Second World War, Mallory developed and manufactured radio noise filters widely used on aircraft and vehicular equipment required by the armed forces. These noise filters used large quantities of paper capacitors which became the bottleneck in their production, forcing us to install a complete unit for the manufacture of this type of capacitor.



Obviously, in such an emergency and under the severe priority restrictions imposed at the time, the equipment installed was restricted to simple rather than automatic types and was designed for making only the particular capacitors needed. We did a remarkable job in providing good capacitors on such short notice and took care of war orders for these types, in addition to our own filter needs.

By 1946 it became apparent that military equipment had to be made smaller, lighter and far more dependable. The missile age was fast approaching and Mallory was quick in contributing the now famous Type XT tantalum capacitor.

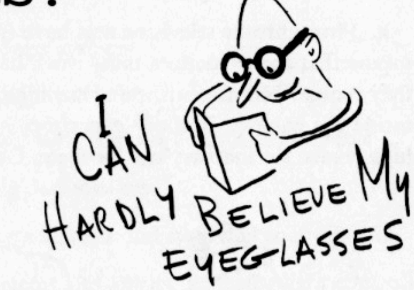
The XT type utilized the tantalum pellet technique and provided miniaturization with extreme reliability and at a temperature range from $-55°$ to $+200°$ Centigrade (twice the boiling point of water).

Here at last was a capacitor that could stand the temperature, shock, vibration, and altitude in a size and weight desired by the armed forces.

Naturally, the Mallory Capacitor Company is continuing to even a greater degree the research and development work which fostered these many contributions to this industry.

■ **CHAPTER 5**

WHO USES MALLORY CAPACITORS?



All electrical devices depend on one or more of the three basic electrical components—resistance, capacity and inductance. They are, so to speak, the bread and butter items in this industry.

So you see—as a manufacturer of capacitors—we are in a rather stable business and, incidentally, a very competitive market.

By now, everyone knows that our capacitors go into radio and television equipment. As you will remember from the first part of this booklet, they do the filtering and by-passing work in such circuits.

Perhaps, however, the following facts may surprise you

a. Since VJ day, we have been making a major percentage of all the electrolytics used in television!

b. From 800,000 television sets produced in 1948, production has grown to over 7,000,000 in 1960.

c. In each of these receivers there were as many as four large FP capacitors, three to six small FP and TC capacitors and almost an even hundred paper and mica capacitors!

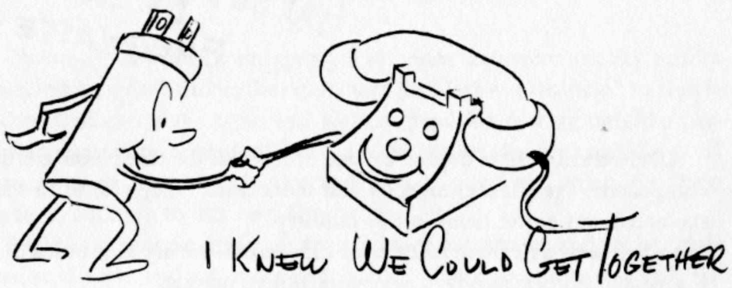
d. Color television uses several times as many capacitors of all types as were used in monochrome (black and white) receivers.

e. We regularly supply such outstanding companies as RCA, Motorola, General Electric, Hallicrafters, Bendix, Westinghouse, Philco, Zenith, Admiral, General Motors, etc.

f. We also supply practically every big name in the air-conditioning field, including Chrysler, Frigidaire, Kelvinator, York, General Electric, Lennox, etc. These concerns use both paper and electrolytic types.

g. The quality of the capacitors we make is universally considered above that of any other brand. In some cases, Mallory capacitors operate excellently in applications that would quickly destroy other makes.

h. Monochrome television sets have from 12 to 20 vacuum tubes. This means that the capacitors must work harder to provide the high current they require and also withstand the high temperature (185°F) they create inside the cabinet. Mallory capacitors just have to be good to earn the high regard the industry has for them. Color TV uses from 20 to 30 tubes!



But radio and television are only one field where Mallory capacitors are used. There is the telephone field where the capacitors we make for Western Electric are used. Over 25 years ago when we suggested electrolytics to Western Electric they smiled and said no! They explained that they owned and must service the entire equipment in the Bell System and could not tolerate components of less than 20-year life. At that time an electrolytic was considered a one-year capacitor. So we made a 20-year capacitor! Today, Mallory and one other supplier are considered the only reliable sources.

Many well known and some rather obscure devices use our capacitors of which the following are typical:

1. Electron Microscope (magnifies over 200,000 times against 2500 for regular microscopes)

2. Lie detectors—for criminal investigations

3. Electro-cardiographs for measuring the electrical impulses from the heart beat

4. X-ray power controls

5. Cathode ray testing equipment

6. Juke boxes and wired music

7. Aircraft, Marine, Broadcast, Television transmitters and relay towers

8. Inter-office and public address systems

9. Talking motion picture equipment

10. Recording thermometer and other remote control instruments

11. Seismographs for recording earthquakes

12. Teletypewriters, calculating machines and stock ticker equipment

13. Fire and burglar alarm systems and automatic traffic-light controls

14. Radio noise suppression in autos, boats, planes and military equipment as well as for household appliances

15. Electric fence controllers—to keep cattle from straying

16. Wind-operated and gasoline-powered power supplies for farm use

17. Electric-eye equipment for opening doors, color grading and sorting and many other duties

18. Electrical-welding and electronic welding timers

19. Photo-flash equipment for high-speed photography

29. Electric motors used in refrigerators, air conditioners, deep-freeze units, washing machines, machine tools, door openers, elevator controls, electric hoists, oil burners

21. Radar, Sonar, Loran and other navigational equipment

22. Oil prospecting and other geophysical devices

23. Guided missile mechanisms

24. Satellites and space probes

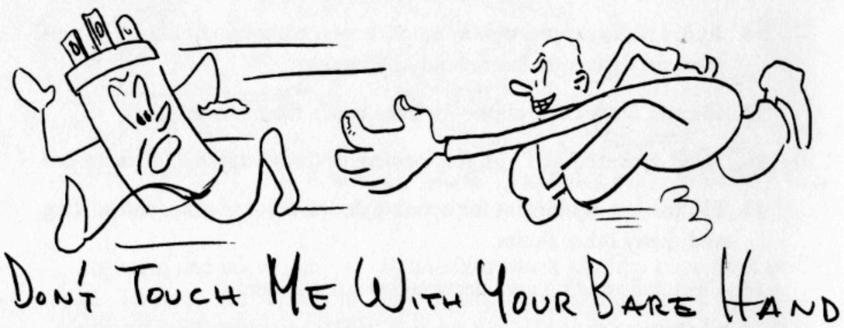
In all, you can see that the products we make reach out into practically every home and business establishment, and now into outer space as well. Many of these applications are vital. A failure can be extremely costly, sometimes even causing loss of life.

For this reason you will want to know what can be done to avoid unnecessary losses in the field. The following chapter is devoted to the things that cause trouble and what can be done about them.

■ CHAPTER 6

WHAT CAUSES CAPACITORS TO FAIL?

CHEMICAL PURITY



Most of us can understand what hospital cleanliness means and would be horrified at the slightest laxity on the part of nurses, attendants, etc. It is not an exaggeration to say that hospital cleanliness (which concerns sterile or bacteria-free methods only) is wholly inadequate for processing and handling electrolytic capacitors.

The major enemy to guard against, from the chemical side, in making capacitors is chlorides (common table salt) although other impurities are involved to a lesser degree. It is necessary that the *total* chloride content in the finished capacitor be kept within one part per million! In ordinary language this is "just a trace." Maintaining this extremely low level calls for a great deal of cooperation between our material suppliers, our handling methods, and those who perform the many operations.

When the chloride limit is exceeded, even slightly, the capacitor starts to corrode or chemically disintegrate inside the tube or can. Often the presence of corrosion cannot be detected by final inspection and the units are placed in service in a defective condition. This causes early failure through internal short or open circuit.

Such failures are costly, in any event. They often cause loss of good will for our customers who, in turn, lose faith in us.

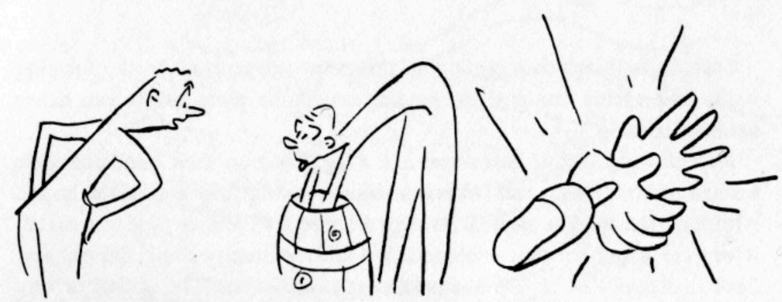
A capacitor failure in the field often has serious consequences. A motion picture show or a public-address system can be stopped completely by a capacitor failure. An electric refrigerator might stop and ruin the food or an oil burner go out of commission and allow the water pipes to freeze, or perhaps a ship or plane in distress cannot make a radio call for help. These and many other incidents have happened too many times.

Since the human hand is constantly perspiring (and perspiration is loaded with salt) it should *never* come in contact with any vital part of the capacitor. The amount of salt deposited by a finger print is enormous compared to the amount that can be tolerated. Furthermore, it is *concentrated* in one spot which means it can easily cause trouble within 24 hours after the capacitor is placed in service.

For this reason salted peanut dispensers cannot be allowed in our division. It is even undesirable to eat lunch in the working area. However, it is felt that an understanding of the hazard involved and an honest effort to cooperate will permit controlled luncheon activities as in the past.

Smoking, as you know, is permitted under certain conditions in our shop. Believe it or not, the tobacco and even the smoke contains enough chlorides to contaminate the capacitor ingredients.

Frankly, wearing gloves is a nuisance—it slows down handling of parts and they are not very comfortable. However, the rubber and cloth glove regulations must be observed. They are the best insurance we have that our quality will be up to the standard we know is necessary. And remember, gloves loose their protective ability when they get contaminated with dirt and grease, both of which pick up and carry salt.

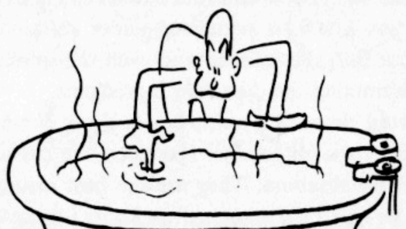


Here is an example that shows how easy it is to cause destructive contamination.

One of our associates was dipping boric acid from a barrel with his *bare hands* and dumping it into the pitcher. He had a clean scoop and a new pair of gloves but they were not being used. When cautioned about it he promptly replied that the boric acid didn't seem to bother *his hands* at all!

FOLLOWING INSTRUCTIONS

No well-meaning person would knowingly do, or neglect to do, anything that would cause loss of profit or failure of the capacitor in the field. There are many apparently insignificant things, however, that occur without the full realization of the consequences. Some of these are detailed in the balance of this chapter.



Such little things as maintaining the exact temperature in the forming baths and ageing troughs, or winding an anode plate askew can cause loads of trouble.

Recently one of our customers had a legal suit on their hands because a small radio blew up and ruined the plaster ceiling and wall of the home. Although the trouble started through a defective rectifier (not our make) it was *our* capacitor that exploded. We will eventually stand the bill and have to struggle to regain our customer's confidence. The capacitor was completely destroyed in the explosion, but from past experience we know it was caused by either an anode plate askew in the cartridge or too much wax interfering with the vent. Had the operator noticed this, when winding, and thrown it out or excercised more care in wax pouring—all this would have been avoided.

The following operations are now listed separately for easy reference:

INCOMING INSPECTION

Diligence in chemical analysis of incoming materials such as boric acid, ethylene glycol, etc., has a great deal to do with the long capacitor life for which Mallory capacitors are noted.

Checking materials for mechanical conformance to our specifications helps keep down rejects in assembly and consequent financial loss to us all.

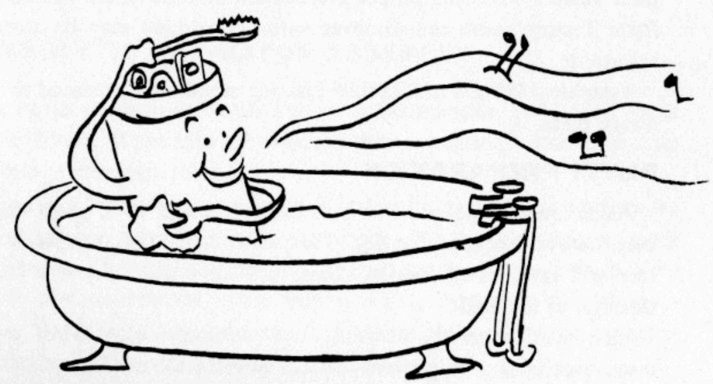
Carelessness here starts the whole show off on the wrong foot.

ETCHING AND SPRAYING

This is the first operation after the foil or spray wire has been checked for purity. If the control becomes lax or the ratio checks are inaccurate, thousands of capacitors may be rejected for *low* capacity and become a total loss.

Even though low capacity is discovered right after forming—large rolls of expensive anode plate may be lost. One roll is worth at least $400.00. Handling the plate without gloves after spraying or etching is sure to lower its ultimate quality.

Poor etching may produce fragile plate that may tear in the forming baths, in turn shorting the generators. Repairing or replacing generators can cost anywhere from $1,000.00 to $25,000.00.



FORMING BATHS

It is here that the oxide film is formed on the anode plate. Since this oxide becomes the only insulation used in the final capacitor, this operation is probably the most vital of any in the Electrolytic Capacitor Division.

This is the first operation that is seriously affected by impurities and cleanliness in handling is extremely important. The chlorides picked up here are generally fairly well diffused as compared to handling in assembly. This means a *general* shortening of the life *of all* capacitors made from the contaminated anode plate rather than isolated but rapid failure from assembly contamination.

Besides losses due to contamination, improperly processed anode plate causes the loss of thousands of finished capacitors whenever such plate passes through assembly undetected. Losses in ageing have been as high as 50% at times due to equipment difficulties or carelessness in this operation. The life in the field is also curtailed sharply from trouble that starts here.

Such things as a slight deviation from bath temperature, chemical composition, etc., severely affect the quality of all the capacitors made from a given roll of plate. Often a capacitor with *four* different anodes has to be scrapped in large quantities because *one* anode out of the four cannot pass the final test. Large areas of plate may be spoiled if baths are stopped without taking suggested precautions relating to flagging, etc.

Improper drying of anode plate causes rapid deterioration in storage and consequent loss of many capacitors. Parasitic oxides form on the plate surface when the proper precautions are not taken. Alertness in the Plate Testing room can discover variations which may be corrected by reforming.

Roughly *$3000.00 to $7000.00* loss per month can be traced to defective anode plate.

PLATE PREPARATION

Aside from contamination by handling, which is of great importance here, care in storage is an added responsibility. Plate that picks up moisture will cause great loss in ageing and have short life if it finally gets through to the field.

Identification mixups obviously are extremely costly. They are seldom discovered in time to prevent the loss of twice the number of units at first involved. This happens when plates are mixed between two batches of different capacitors.

Plates should be kept clean and covered according to instructions.

ELECTROLYTIC ROLLING DEPARTMENT

Here is another spot where care and good sense can save many dollars and prevent trouble in the field as well. Mixed anodes and improper sequence cause complete loss of all capacitors rolled before the error is discovered. Many times this has involved 5000 or more capacitors. (Average sales price $0.75 each.)

Neglecting to see that *all* paper separators are intact or neglecting to use patches causes wholesale breakdown in ageing and short life for those that get through.

Anodes that get out of line (askew) seem innocent enough but are really troublesome indeed. If they extend past the paper at the bottom they may short out to the cathode foil and pass out in ageing—or later when Grandma is listening to her favorite swing band!

Worse than that, those that are even a little out of line cause what is known as "coupling" between anodes. This causes whistling noises in the radio and another nasty trouble called "motorboating." The radio manufacturer spends hours trying to locate the trouble and when he does—heaven help our salesman!

Still worse is the possibility of explosion in the field, sometimes caused by anodes out of line and torn or missing separators.

Don't ever touch the cartridges with the fingers or dirty gloves. The salts deposited by such action stay concentrated right in one spot. This is sure to ruin the capacitor as soon as it gets in service.

ELECTROLYTIC CAPACITOR ASSEMBLY

Here again we have to watch out for contamination and a new angle has been added. If the tabs are touched they eat through later and drop off, causing immediate failure.

In cardboard tubulars, care must be taken to keep the joint between tabs and copper wires free from electrolyte. Neglect here causes quick tab corrosion. Cartridges should not be laid on the benches or in dirty trays for obvious reasons. After impregnation, cartridges should never be left in the open for any great length of time or they will absorb moisture and corrode. That's why we have storage ovens.

Care should be exercised that colored wire leads get assembled to the correct tabs. If joints are not tight—intermittent circuit troubles will develop.

ELECTROLYTE PREPARATION AND AGEING

Contamination here ruins whole batches of capacitors! Cleanliness is essential and frequent chemical checks must be made and corrections quickly accomplished.

Boiling points and times must be diligently followed as one degree change in temperature or one minute off in time makes a very considerable change in the capacitor quality. The moisture content is extremely critical.

Here, as in the forming baths, slight errors that do not immediately cause rejections or drastic field trouble, do affect the over-all quality of our product and this is sure to be noticed eventually. Use of the wrong electrolyte is unpardonable.

PAPER DIELECTRIC WINDING

Here proper alignment of foil and paper and avoiding wrinkles is extremely important. Both can cause breakdown at final test or in the field. Misalignment, in addition, causes a variation in capacity likely to ruin the unit for the use intended.

Use correct foil lengths (turns) and proper paper thickness or rejects for off-capacity will occur. Too thin papers will also cause breakdown.

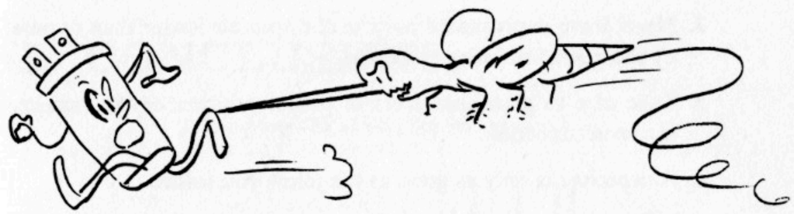
Incorrect tension when winding can cause off-capacity and sometimes breakdown. Windings that are too loose may be too big to fit the container.

Dust and other foreign particles must be kept out of contact with the capacitor cartridge while winding. Failure to do so will cause shorts and blowouts.

Care should be exercised in handling both paper and foil to prevent wrinkles and tears especially at the start of the winding.

Since the number and thickness of papers determines the voltage the capacitor will stand, you must be alert to catch a broken layer for improper thickness.

Keeping the winding arbors clean and free from burrs will eliminate rejects caused by breakdown at the start of the winding.



PAPER DIELECTRIC IMPREGNATION

Some of our processing operations are very sensitive to contamination and critical to handle. Proper heat must be maintained as well as the vacuum requirements or poor quality capacitors will be produced.

Always be careful to use the impregnant specified and not get them mixed or all units will be ruined.

Vacuum systems must be carefully cleaned and kept tight and the impregnant filtered as specified, or quality cannot be maintained. These capacitors must be kept chemically clean, although for somewhat different reasons than electrolytics. Even though no corrosion is noticed here, the dielectric resistance can drop due to contamination and cause the unit to fail.

A careful check of the temperature, vacuum and oil purity is extremely important.

Always keep containers and drying ovens clean and carefully follow handling instructions.

When impregnating complete capacitors it is extremely important that the impregnating hole be sealed off as soon as the cycle has been completed. Otherwise the capacitor life will be shortened and the insulation resistance and power factor will be adversely affected, and finally, this might be a possible cause for blowouts. Care should be taken *not* to drain any of the oil out of the containers when sealing them.

The following impregnants are used in this department and care should be taken to see that the wrong impregnant is not inadvertently substituted:

Mallotrol A—Aroclor

Mallotrol C—Mineral Oil

PAPER DIELECTRIC ASSEMBLY

Perhaps a check list here would be the best way to show the many things that lower capacitor quality.

1. Look out for dirty work tables—keep them clean at all times.

2. Never leave impregnated parts in the open air longer than required by the operation being performed.
3. Take care to place insulators in proper position or the capacitor just won't function.
4. A capacitor is only as good as the joints you solder.
5. Never mix sections and insulators having different impregnants.
6. When stacking flat sections care should be taken to provide for uniform pressure as otherwise we will have capacity rejects.
7. Packing boards inserted during wet or dry assembly are important to maintain correct capacity, and specifications should be followed carefully.
8. Care should be taken in handling all capacitor sections for rejects will occur from bent terminals, dented cans and ruptured solder joints.
9. It's a good idea to ask when in doubt—never trust to a guess.

■ CHAPTER 7

IN CONCLUSION

(Editors Note—Its all over but the cheering)

I MUST BE GOING

We have many competitors some of whom are as large or larger than ourselves. Our enviable position has been earned by competent engineering designs, careful manufacturing controls, and above average equipment, plus an excellent effort on the part of all those associated with us.

Furthermore, we are noted for having *a sound business policy*. Our customers consider Mallory an outstanding example of trustworthiness in the industry. We will continue to do everything possible to maintain this relationship.

Mallory, for fifty years, has served manufacturers and servicemen as a single source of supply for a wide range of products for electric and electronic applications. The complete line of Mallory-made components covers four broad fields of manufacturing and engineering activity—electromechanical, electrochemical, electronic, and metallurgical. Listed below are the principal Mallory product lines which continually meet exacting requirements of standard as well as special applications.

Batteries, Alkaline
Batteries, Mercury
Capacitors, AC Paper Dielectric
Capacitors, Aluminum Electrolytic
Capacitors, Ceramic
Capacitors, Tantalum
Carbon Controls
Diodes
Electrical Contacts and Contact Assemblies
Inductuners®
Jacks & Plugs
Material for Electrical Discharge Machining
Metals, High Density
Metals, Refractory
Potentiometers
Rectifiers, Silicon
Rectifiers, Silicon Prepackaged Circuit
Resistance Welding Products
Resistors, Vitreous Enamel
Resistors, Film
Switches
Timer Switches
Timers, Interval

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