ENGINEERING AND DESIGN NOTES

1. INTRODUCTION TO CLUTCHES AND BRAKES

With the increase of design integration of electronic control systems with mechanical systems, new concepts of engineering are being developed to simplify the overall equipment and increase its performance with the maximum reliability possible. The mixing of pure electronic circuitry with mechanical operation imposes a great burden on the design engineer in the form of additional knowledge of components that cross the discrete line of difference between electronic and mechanical parts. Electro-magnetic clutches and brakes are one of the most used and least understood of these components. There are several types and configurations of these electro-magnetic devices, each a perfect answer to a particular design problem. Unfortunately, the selection of the wrong unit can lead to needless complications which may downgrade the system performance. It is necessary to understand the various types of electro-magnetic devices that are available and to know their exact functions as applied to the particular system under consideration.

2. DEFINITION OF FUNCTIONS

There are several types of devices for controlling mechanical motions or functions. They can be classified as purely mechanical in operation, or controlled by pneumatic, hydraulic, or electrical power. These notes will deal with the latter for the most part, specifically, the friction disc electro-magnetic devices that are manufactured by Autotronics, Inc. However, in order to give the engineer the broadest possible background, we will describe the basic types of devices that are available for use in the majority of applications.

The definitions deal with the principle functions of a device without regard to the method of controlling these functions.

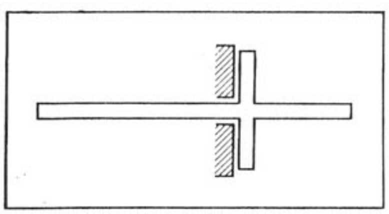


Figure 1: BRAKE

The first device is the brake. A brake will, upon application of controlling power, exert a force that will retard or stop a rotating member or hold a static member against a specific force. The schematic representation of a brake is shown in Figure 1.

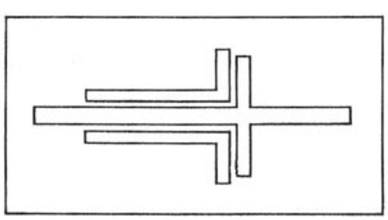


Figure 2: CLUTCH

The next device is the clutch. The clutch, upon suitable command, will couple two rotating or static members together. The automotive clutch is a good example of this type of device. The schematic representation of a clutch is shown in Figure 2.

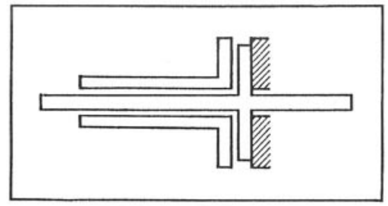


Figure 3a: CLUTCH/ BRAKE

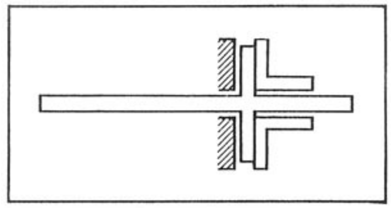


Figure 3b: BRAKE/CLUTCH

The functions of both the clutch and the brake can be combined to give two interdependent actions within the same envelope. This is the clutch/brake unit. When properly applied, the clutch/brake is a very adaptable device which can solve many perplexing design problems for the engineer. The function of a clutch/brake is to either disengage a driving force and brake the driven member, or to disengage the brake member and apply the driving force. This action can occur simultaneously or within a very short interval of time. The schematic representations of the clutch/ brake and the brake/clutch are shown in Figure 3a and 3b, respectively.

Modifications of the above brakes, clutches and clutch/brake units can give action either upon a direct application of the commanding signal or upon removal of the signal. Thus a clutch can be made to engage when energized, or to disengage when energized. The model BF brake and the CF clutch are examples of this "reverse" type of action.

3. MECHANICAL CLUTCHES

The basic types of clutches (and brakes) commercially available are many and varied. In the mechanical field, the friction disc clutch and the toothed clutch are two common types. These units will operate when physically moved or actuated by a mechanical linkage. This linkage can be hand operated, cam operated, hydraulically or pneumatically operated. The familiar hand brake on an automobile is a good example of the friction type. The toothed type is very similar to two gears engaging, or a series of pins on one plate fitting into a set of holes on a second plate.

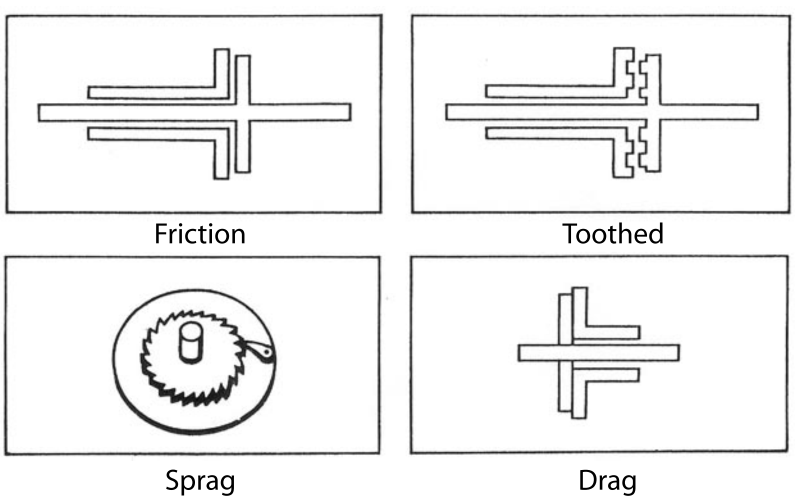


Figure 4: Basic Types of Mechanical Clutches and Brakes

For certain functions, the sprag, or over-running clutch is desirable. The clutching action of the sprag clutch is unidirectional. The application of the clutching action is obtained when the driving member equals or tends to exceed the speed of the driven member. Drag clutches or torque-limiting clutches are used to maintain tension, to limit applied torque or to act as a torque "safety valve" to protect delicate equipment. (See Figure 4)

4. ELECTRO-MAGNETIC CLUTCHES

In the following discussion, it will be important to remember that the operational description of clutches will also apply to brakes and clutch/brake combination units since all the functions are very similar. The data listings contain detailed explanations of particular units of each type described in the preceding sections of this handbook.

Electro-magnetic clutches are divided into three basic classifications: the friction disc type, the hysteresis type, and the magnetic particle type. There is also some interest in the electro-static clutch, but for the purposes of this discussion, the electro-static clutch is included with the hysteresis type.

The friction disc clutch manufactured by Autotronics, Inc. can be considered as an on-off device that will operate rapidly and positively as long as the torque values do not exceed its capabilities. The proper selection of friction surfaces will provide many variations of actions that can combine the functions of torque transmittal and torque limiting.

Since the friction disc type of clutch is the most widely used, a complete and detailed explanation of its operation and application will be given in this handbook. However, in order to understand the wide range of applications of electro-magnetic clutches, a complete discussion of all types of these devices is included.

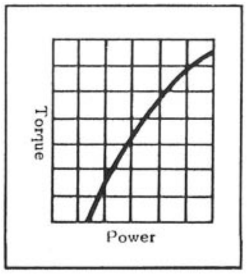


Figure 5: Hysteresis Clutch

The hysteresis, or eddy-current, type of clutch is mainly used for proportional control. The principle of operation of this unit is the formation of a magnetic flux field between two poles. A drag cup made of magnetic or paramagnetic material is interspersed between these poles. The inductance of eddy-currents in this drag cup forms poles opposite those of the field and thus exert a force which tends to move the drag cup as the field moves. The torque of the hysteresis clutch is proportional to the power applied (Figure 5). It is possible to control transmitted speed and torque by simply varying the amount of power fed to the coils of this unit. The hysteresis clutch will slip at a constant rate when the speed and torque remain static. This slippage application is the principle use of this type of clutch. Many test devices use the hysteresis clutch to plot the dynamic operation of servo motors and to measure running torques and speeds at various loads. The no-load friction drag of this type of clutch is very low when de-energized. Some disadvantages of the hysteresis clutch are its relatively large size versus its torque capability, the displacement between the input and output when less than maximum voltage is applied, and its higher cost.

The magnetic particle clutch depends upon the attraction between ferrous particles, either dry or suspended in fluid, when subjected to the field imposed by a coil. As in the case of the hysteresis clutch, the transmitted torque is proportional to the power applied. The threshold of torque transmitted is somewhat higher than the hysteresis type in that it will transmit more torque in proportion to the power applied. The particle clutch is also used when a proportional control is desired. It is capable of higher total torque and is generally limited to relatively low speed applications up to about 2500 RPM.

The friction disc clutch is, by far, the most versatile in that many combinations of functions are possible to fill almost every designed application. A detailed explanation of the operation of the friction disc clutch is presented under "Method of Operation" in later pages. These notes limit the discussion of the application of clutches to the control or instrument field. For the sake of clarity, an arbitrary limit of approximately 300 ounce-inches of torque will be the dividing line between the control applications and the power transmitting applications. This figure is expressed in ounce-inches rather than horsepower or foot-pounds to further differentiate between control and power usage.

5. SELECTING THE CLUTCH

When selecting a clutch, brake, or clutch/brake unit for a system, the engineer has a veritable enigma facing him in the form of data, curves, functions, claims, and counterclaims. In order to break the requirements down to the formulation of an exact specification, the following points will be discussed in the relative order of their importance.

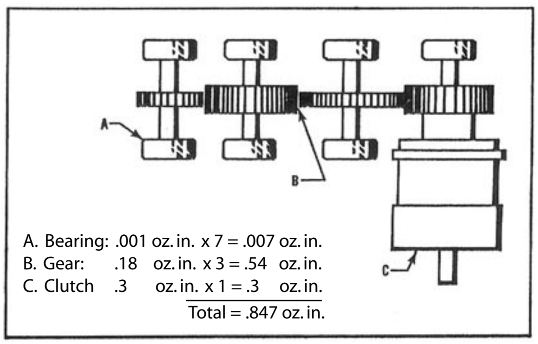


Figure 6: Determining Total Friction

First and foremost, the actual value of torque required to do the job must be determined. If the task is one of merely driving a load at a given rate of speed, the torque required is easily determined by empirical test of the system or the addition of all the drag constants of the components in the system. (See Figure 6)

When the question of acceleration enters the picture, the engineer now has the added problem of inertia calculations. It will be well to remember that most clutch torques are listed as minimum rated torque values and that the manufacturer has included a safety factor in these values. The engineer should not add too great a safety factor to his inertia calculations. The pyramiding of safety factors by the engineer and manufacturer can lead to grossly over-designed units that are wasteful of power, space, and weight.

Secondly, after the torque is determined, the operational characteristics must be determined. Is a clutch, a brake, or a combination of both needed? There are also considerations of duty cycle. Will the unit be engaged for long periods of time, and be disengaged only intermittently? Is it desired that two seemingly independent actions occur at the same time? Is a "fail-safe" type of operation required? These are a few of the questions that must be answered before the right unit can be selected.

After the operational mode is selected, the questions of shaft speed, response time, expected life, power requirements, reversals of rotation and environmental conditions must be answered.

Armed with the answers to the above questions, our engineering staff can recommend the proper unit for the particular application. With a little experience, the engineer can determine which unit is best for each job when the above answers are all available.

A tabular listing of various operational modes and their schematics is given in Figure 7. Further operations are possible by combining two or more models into one package. An example of this is the combination of a clutch with a brake/clutch to give the following characteristics:

a) Shaft braked, input flange on one end free and input flange on other end coupled to braked shaft.
b) Coil #1 energized, shaft free and coupled to input flange on each end.
c) Coil #2 energized, normally clutched input flange free, shaft braked.
d) Both coils energized, functions (b) and (c) combined.

6. SPECIALLY DESIGNED DEVICES

Autotronics can furnish several modifications of the clutch, brake or clutch/brake combination to fit the system packages. These modifications are:

1. Shaft length to your requirements.
2. Adjustment of clutch and/or brake values for higher torque or lower slip torque as required for the application.
3. Furnishing pre-assembled gears in place of the input flange, and pinion shafts or gears on the output shaft.
4. Special mounting configurations for attachment to synchros, servo motors, gear heads, drive motors, counters and potentiometers. These complete assemblies are also available to your requirements from Autotronics.
5. Special coil voltages from 6 volts D.C. to 150 volts D.C.

The shaft length can be furnished to the particular requirement. The handbook "D" or "K" dimension is given for the standard -1, -2, or -3 units. Longer or shorter lengths will be assigned special dash numbers. The tolerance on the shaft extension should be ±.020 inch. Closer tolerances can be held on these units, but since the cost would increase for these special tolerances, it is best to design for standard tolerances if the close tolerances are not required. A common problem is over-specification of these dimensions when the tight tolerances are not really required. Additional shaft configurations such as milled flats, slots, drilled holes, and stepped diameters or snap ring grooves can also be furnished.

When extra long shafts are used it is always best to support the ends with an additional bearing outboard of the gears. This will be covered in more detail under APPLICATIONS.

The values given for clutches, brakes and clutch/brake combinations in this handbook represent the minimum values as produced for our standard devices. These values can be changed to satisfy the special requirements of a particular application. The clutch torque can be increased and the brake torque decreased on clutch/brake units, or they can be changed in the opposite direction. It should be remembered that the clutch torque plus the brake torque equals the total torque available from the particular unit. The values of clutch and brake can be changed, within certain limits, as long as the total torque does not exceed that of the standard unit as shown in this handbook. Autotronics can also furnish special friction facings to take the place of slip devices within the equipment. If there is an inertia load that would exceed a certain torque value during starting or stopping a system, Autotronics can furnish special power facings to absorb the inertia present and yet maintain a desired torque value. In all cases, the engineering staff at Autotronics should be consulted for their recommendations when a special torque or special circumstance is desired. Over the years, Autotronics has developed and evaluated hundreds of combinations of friction surfaces and special processes to provide special operating parameters for our customers. Please feel free to use our engineering consulting service at any time. It is always best to have the components for a system designed along with the development of that system so that all the determinations can be made relative to adjustments required before the system is in final form.

By using integrated assemblies such as gears in place of the input flange, space, weight and cost savings are accomplished in the final assembly of the system. Autotronics can furnish custom gears through Class III Precision and Ultra-Precision IV mounted on the clutch in place of the regular input flange if the major diameter of the gear is smaller than the mounting hole diameter in the equipment (See Figure 8). If the gear must be removable, the gear can be supplied separately or mounted and marked for the best concentricity of the assembly. Output gears can also be supplied as pre-assembled or separate items. By furnishing both clutch and gear, the maximum compatibility is assured in the assembly of the final equipment. In many cases, the savings in inventory and handling alone have more than offset the cost of the gears. Autotronics can cut precision gears from most machinable metallic or non-metallic materials.

model	description	typical curve	schematic
"B"	BRAKE		
"BF"	BRAKE		
"MB"	CLUTCH-BRAKE		
"MC"	BRAKE-CLUTCH		
"C"	CLUTCH		
"CF"	CLUTCH		
"MBB"	CLUTCH-BRAKE		
"CBC"	CLUTCH-BRAKE		
"MBC"	DUPLEX-CLUTCH		
"MCC"	DUPLEX-CLUTCH		
"CCC"	TRIPLEX-CLUTCH		

Figure 7: Chart of Models, Names and Schematics

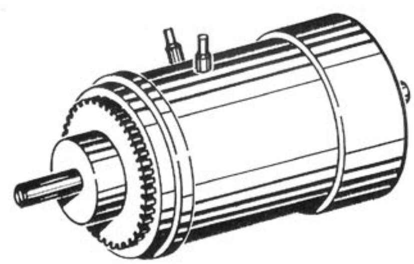


Figure 8.

Autotronics has designed many special mounting adaptors to enable the designer to have a single multipurpose component instead of many parts to mount and interconnect. Examples of these are: the clutch-pot module, servo motor-brake module, synchro resolver and spring return-clutch module. More of these special configurations are shown in the Custom Units section of this handbook. Many of these designs were developed as a specific requirement for a particular operational mode in a system. A distinct engineering department is maintained for the design and application of these special devices. This independent engineering facility has its own model shop and "White Room" assembly area enabling Autotronics to offer unsurpassed service in the development and manufacture of these special devices.

The standard operating voltage of the Autotronics' electro-magnetic clutches, brakes and clutch/ brake combinations is 24 to 28 volts D.C. Other operating voltages can be furnished on special order. Generally, the lowest voltage used is approximately 6 volts and the upper limit is approximately 150 volts. When other voltages are specified, the response time of the electro-magnetic device will vary somewhat from the nominal range given in the various listings. Operation of the clutches and brakes from alternating current supplies is made possible by using a full wave diode bridge rectifier network. This network can be supplied as a separate component or can be built into the clutch or brake with the addition of approximately 1/8 inch to the overall length of the device.

7. INSTALLATION

Autotronics' precision clutches, brakes and clutch/brake combination units are very rugged devices that will deliver reliable service when properly handled and installed. There are a few precautions that should be noted to assure the user of maximum reliability and service.

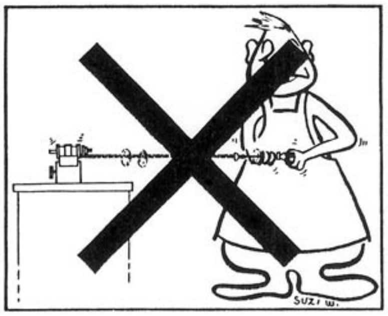


Figure 9.

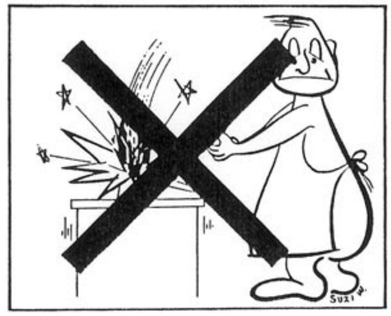


Figure 10.

When mounting gears to the input flanges, care should be taken to use the proper length screws. A screw that is too long will pass through the flange and gear and exert considerable pressure against the body. This pressure is transmitted directly to the bearings supporting the flange and will damage them. Similarly, tapping the clutch or driving it out of the assembly with excessive pressure on the shaft or flange will also cause bearing damage (See Figures 9 and 10).

It is generally not realized that tremendous "G" loadings can be generated by merely tapping on a unit. Even the handle of a screwdriver against a hard surface will develop 5OOG shocks when applied with moderate blows. When seating or removing a clutch, always exert even pressure in preference to hitting or tapping. The removal of gears, as well as the mounting of them, should be done with moderate pressure rather than "lightly" tapping them with a small hammer.

It is common practice to drill and pin gears to the shafts. Precautions should be taken to prevent drill chips or coolant from entering the clutch. The shaft and clutch should be supported in such a manner as to absorb the stresses and vibrations resulting from the drilling operation. Masking of some sort should also be used to prevent the chips from working into the unit. Blowing off the chips with air pressure is definitely not recommended, as this almost always drives some contamination into the unit. A clean brush is recommended as the best way to clean off the chips and dirt. When pinning gears, pressure rather than tapping is recommended. Tests have shown that a pin that is firmly pressed into place has equal holding power to a pin that has been staked into place. Tapping and staking will generate sufficient forces to damage the high quality instrument bearings used in these units. If the exact hole location is known, the shaft can be pre-drilled by Autotronics using special equipment and fixtures. After any machining operations on a completed unit, it is completely inspected before shipment to guarantee perfect performance. Mating gears can also be supplied pre-drilled and located.

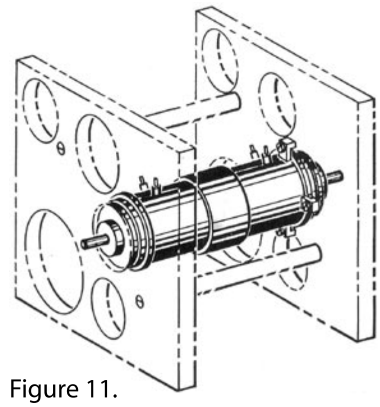


Figure 11.

Clutch/brake units and duplex clutches (models MB and MBC, for example) have servo mounting flanges on both ends. Sometimes both flanges are used when the unit is mounted between two plates. If this method is to be used, careful attention should be paid to the possible tolerance build-up on the clutch and the plate separators. If the distance between the two plates is greater than the "B" dimension and the clutch is clamped by both flanges, there is a possibility that the clutch may be pulled apart enough to impair its performance. (See Figure 11.) On the other hand, if the clutch "B" dimension is greater than the plate separators, there is the possibility that the plates may buckle and would affect the proper operation of the gear train.

There are many systems that incorporate mechanical stops to limit over-travel of counters, potentiometers, or other devices. When the stop in this system is after the clutch drive position, it should be noted in the design requirements of the clutch. There are two reasons that this information should be given:

1. The clutch should not develop too much torque that would result in damage to the end stop or to the component containing the stop.
2. The clutch should contain special slip facings that would prevent excessive wear on the surfaces if they were slipped for long periods of time at high speeds.

8. INSPECTION

A complete inspection record is packed with every Autotronics' precision clutch, brake and clutch/ brake unit. It is sometimes necessary to reinspect a clutch or brake after it has been in service for some time or has been removed from an assembly. The main points of inspection should be the operational characteristics. The electrical characteristics of the clutch or brake will not change appreciably, i.e., coil resistance, response time, pull-in and drop-out voltages, and insulation resistance, unless some damage has been done. The mechanical characteristics that should be checked are: the clutch torque, brake torque, no-load drag torque, shaft runout and input hub runout. The clutch and/or brake torque measurements will indicate if excessive wear has taken place while the no-load drag torque and shaft and hub runout measurements will show if any external damage was done to the unit. All measurements should be referred back to the original inspection record for comparison.

There are no maintenance procedures for these electro-magnetic devices since they are essentially a single "sealed" component. If any repair is to be done, the unit should be returned to the factory for inspection and repair. Our service department will inspect the unit and determine if it is repairable. If desired, a complete analysis can be made to determine the cause of the malfunction. Many times a clutch or brake malfunction will lead to a complete analysis of the application with the result that the clutch or brake is modified slightly to meet the unique requirements of that system. Autotronics has been able to improve the performance of many systems when close liaison was possible between the design engineer and our technical staff. Our applications engineers are available for consultation anywhere. Extensive applications experience on all types of systems makes our engineering staff fully qualified to help in the design of electro-mechanical assemblies.

9. METHOD OF OPERATION

The Autotronics' electro-magnetic clutches, brakes and clutch/brake units all operate on the same principle: that of an electro-magnetically controlled armature that will engage or disengage another surface. For the explanation of how the device operates, we will discuss the operation of the brake/clutch model MC which is the basic building block of almost all other types shown in this handbook. Refer to Figure 12, the cross sectional drawing, for this discussion.

The input gear flange (1) is the means of driving the input shaft (2) which will rotate freely within the housing.

The friction surface (3) is separated from the armature (5) by an air gap.

The armature is attached to the output shaft (4) by means of a unique flat spring (6) that allows no rotational displacement between the armature and the shaft. Therefore there is no backlash possible in the clutch.

The output shaft is restrained from turning by the friction surface (7) that is in contact with the end cap (8).

When the unit is energized, the coil (9) builds up a magnetic field that pulls the armature (5) towards the body and thus releases the brake tension and engages the input shaft friction surface (3).

Since there is now an air gap between the end cap and the armature, the output shaft driven by the input shaft is free to rotate.

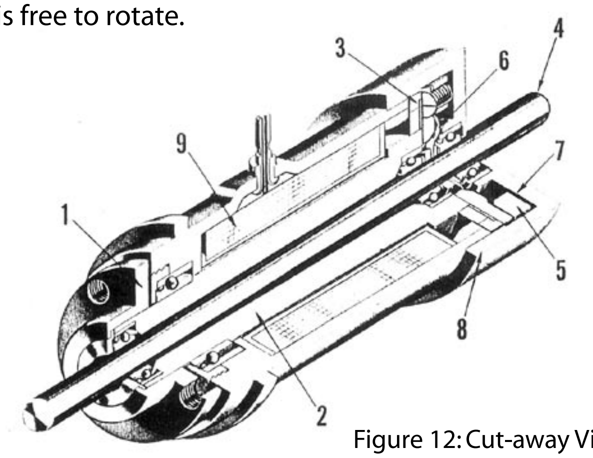


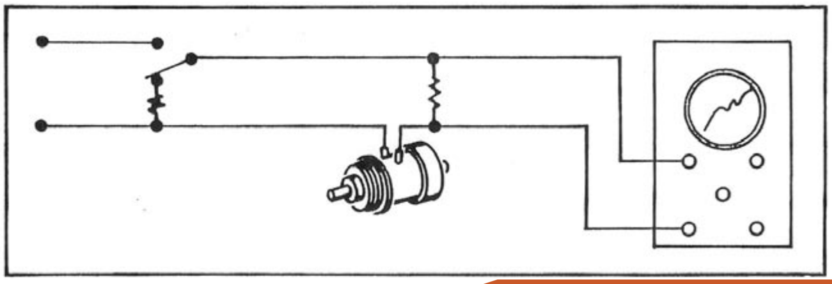
Figure 12: Cut-away View of "MC" Brake/Clutch

The movement of the armature does not take place at one time. It starts to leave the end cap at one point on the periphery and "walks" towards the input shaft. This "walking" action is designed into the clutch to provide a holding feature that will never let the output shaft be free to rotate without either the brake or the clutch partially engaged. As the magnetic flux builds up, the armature continues its motion until it has fully completed the transfer from one position to the other. The same action takes place when the clutch is de-energized. However in the case of the MC model, the release time is much shorter than the engage time.

10. RESPONSE TIME

The response time is generally accepted to be the total time required for the clutch or brake to engage when energizing power is applied to the coil, or for the action to take place when the coil is de-energized. There are several methods of measuring this response time. Some involve rather intricate mechanical and electrical setups and do not lend themselves to production or receiving inspection methods. Autotronics uses the following method to measure both the "pull-in" and "drop-out" time of electro-magnetic devices (See Figure 13).

Figure 13.



relatively simple to operate, and the results are consistent and repeatable. The application of power will gradually increase the flux density across the air gap until the armature starts to move across this gap. The movement of the armature changes the inductance of the coil assembly and is reflected as a downward "pip" on the oscilloscope. The flux still increases and the armature completes its movement across the air gap until it is completely engaged with its associated restraining surface. The rate of flux build-up then changes when the inductance is stabilized and the curve builds up to its upper limit. At the point that the armature ceases its lateral travel, a second "pip" occurs that indicates that the armature is fully engaged.

The de-energized, or drop-out, response time is also measured in the same way by imposing the back EMF across a resistor. The gradual deterioration of the magnetic flux field is traced on the oscilloscope until the armature starts its return movement. The flux deterioration is then upset slightly which is reflected as a change in inductance that forms a "pip" on the screen. As the flux decreases further, the armature completes its return movement, thus producing a second change in inductance and a second "pip" on the oscilloscope screen. The total elapsed time from the application or removal of energization to the trailing edge of the second "pip" constitutes the response time for either pull-in or drop-out. It is a characteristic of the pre-loaded units, i.e., MC, BF, CF, MB and MBC, that the drop-out time is much shorter than the pull-in time. The usual drop-out time in this case is approximately 50% of the pull-in time.

The illustrated response times represent nominal values and are subject to nominal variations. Slight changes in the air gaps and in tolerances of mechanical parts will vary the response time within a given size and type of unit. The table lists typical response times possible in all sizes and types of units. This table represents an analysis of approximately a thousand units.

TYPICAL RESPONSE TIME CHART - MSEC

STANDARD MODEL		PULL IN			DROP OUT		
		(AVERAGE)	MAXIMUM	MINIMUM	(AVERAGE)	MAXIMUM	MINIMUM
B	6	9	11	5	8	15	3
	8	11	15	7	24	47	6
	10	23	35	12	26	46	6
MB	6	13	16	10	3	4	2
	8	26	38	20	8	11	7
	10	38	49	28	9	16	6
MBC	6	13	15	11	3	4	2
	8	22	29	13	7	9	3
	10	26	44	17	12	21	8
BF	6	14	20	9	4	7	3
	8	24	28	19	4	6	3
	10	34	41	25	9	23	5
C	6	11	14	9	6	9	4
	8	13	16	8	12	20	8
	10	17	28	8	13	24	8
MC	6	14	16	10	3	4	2
	8	23	26	19	7	9	5
	10	27	36	14	9	12	4
CF	6	14	17	11	3	5	2
	8	22	28	13	4	8	2
	10	28	40	10	7	11	4

The response time can be varied in case there are special requirements for torque or mechanical considerations. If a specific response time is actually required in an application, this must be shown as a specific requirement. Units can be selected to obtain the specific response time desired. If a normal range in the response time is acceptable, the cost will be standard. If a special selection is required, an extra charge will be levied.

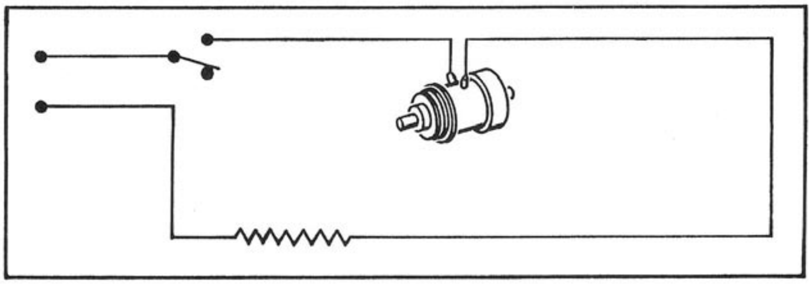


Figure 14.

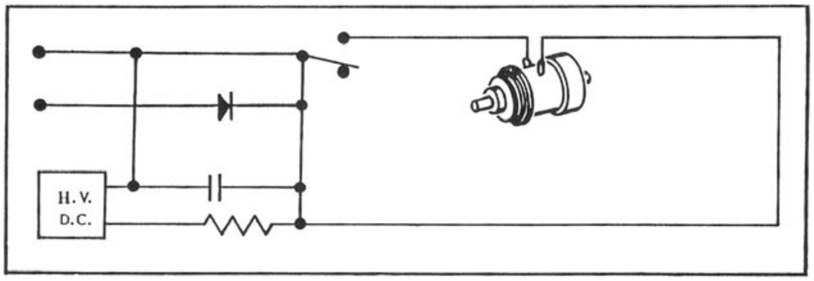


Figure 15.

There are many applications that require a shorter response time than is possible in a given unit. There are two ways to shorten the energized time of a unit. The first, and simplest, is to use a coil voltage that is lower than the supply voltage and insert a series (current limiting) resistor (See Figure 14). This method will shorten the response time approximately 25% to 50% depending upon the application. The second method is to use a high voltage "kick" (See Figure 15). This method applies a quick surge to the coil that overcomes the normal electrical impedance inertia. Response times as low as 1 millisecond are possible on the larger units with this method. The actual response time with this method is an empirical rather than a calculable quantity since there are so many variables that enter into the circuit. The oscilloscope method (See Figure 13) is also applicable to the measurement of this time value.

11. GENERAL CHARACTERISTICS

All units described in this catalog meet all of the following characteristics:

1. Zero Backlash.
2. No axial displacement when energized or de-energized. End play when measured with 5 oz. reversing load - .001" maximum.
3. No angular displacement when clutching or braking.
4. Instrument ball bearings Class ABEC 5 or better used throughout precision units.
5. Output shaft available on either or both ends.
6. Units meet all applicable specifications of MIL-E-5272B and C Environments.
7. Normal operating voltage, 24 to 28 volts D.C. (Special voltages available to order from 6 volts thru 150 volts D.C.)
8. Coils insulated for 500 volts R.M.S.
9. Coils and terminals are completely impregnated and potted into position.

10. Life in excess of one million operations. Tested at 60 cps.
11. All units will maintain minimum guaranteed torque throughout ambient temperature range of –55°C to +125°C.
12. Input flange tapped for gear or coupling, no alignment problem.
13. Input and output shafts are concentric with the servo-mounting pilot within .0015" T.I.R.
14. Gears can be provided in place of the input flange.

Special attention is called to the unique characteristics of the MB and MC units. A torque load of less than cross-over or combined clutch-brake value will not release when switching from clutch to brake or back again. In servo applications this assures perfect alignment of the follow-up after decoupling of the positioning drive. In other applications it allows decoupling while holding a load without a change in position.

An inspection record accompanies every precision device shipped by Autotronics. Complete inspection and recording of all mechanical and electrical characteristics assures that the highest quality will be maintained on all units.

A copy of each inspection record is kept on permanent file at Autotronics where experienced personnel can obtain statistical information used to constantly improve the service life of these units through design and process control. Autotronics is one of the few manufacturers offering this service of complete, permanent, final inspection recording. In addition to this inspection record, a tabulation of each unit is maintained listing the customer and shop order.

12. APPLICATIONS

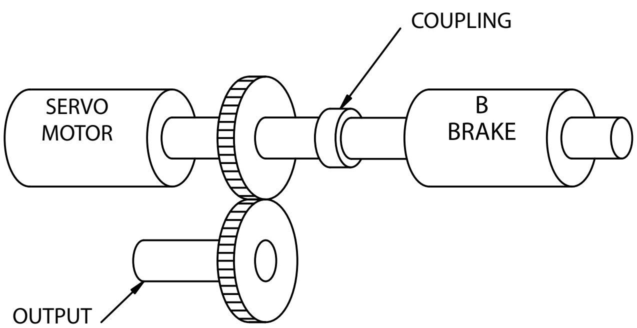
The applications for Autotronics' clutches, brakes and clutch/brake combination units are many and varied. A few of the most common ones will be presented here in order to give an idea of the versatility of the Autotronics' electro-magnetic devices.

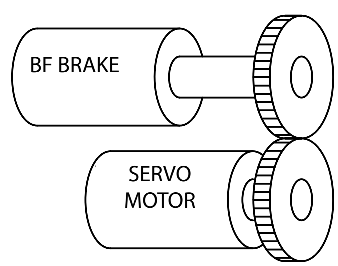
The adaptation of these units to the particular system illustrated is limited only by the resourcefulness and imagination of the engineer. Autotronics has developed novel packaging methods to make the electro-magnetic device an integral part of the total assembly. For the sake of clarity, the applications here show the electro-magnetic device as a separate unit. Please bear in mind that the functions can be included in a common package or envelope as a custom-made unit.

1. Brake (Model B or BF)

In this application, the braking action is used to stop a motor drive in one of two ways, depending upon the function desired.

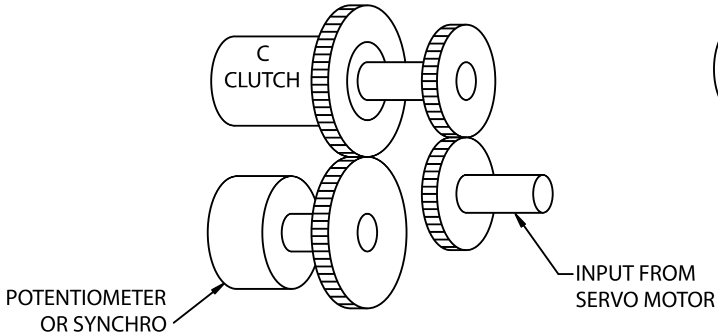
a) As a brake to stop the motor when power is applied to the B unit.
b) As a brake to stop the motor when the power is removed (Fail-safe operation).

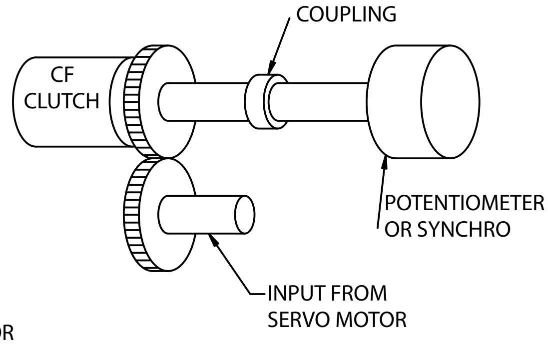




2. Clutch (Model C or CF)

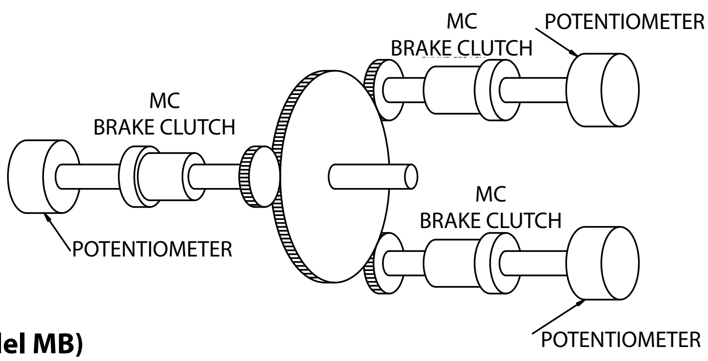
Using a clutch, several operations can be accomplished from one power drive system. The individual segment of the control system can be coupled to the drive upon energization of the clutch. In the case of many segments being driven at the same time, the Model CF Clutch can be used to decouple any segment when the coil of the clutch is energized.





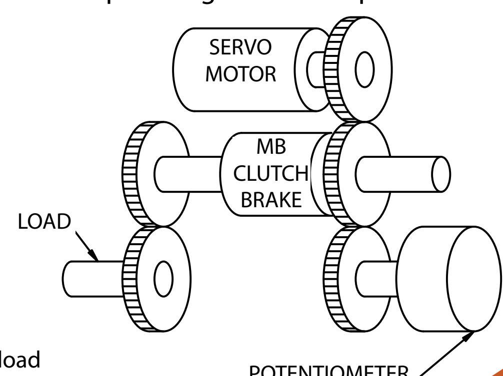
3. Brake/Clutch (Model MC)

This application demonstrates a common control function that is required in many systems. The driving force is distributed among many points, but the setting of an individual potentiometer is required upon suitable command. Energizing the MC releases the brake holding the potentiometer and clutches the shaft to the driving system. When the potentiometer is positioned at the desired point, the clutch is released and the brake is applied when the coil is de-energized. Using this method, one servo motor and nulling system can be utilized to set many functions by means of simple switching circuitry.



4. Clutch/Brake (Model MB)

Some applications require maintaining a relationship of a driven load and a feedback device. On occasion, the relationship may be adjusted to change operating conditions. The MB clutch/brake will allow this correcting action to occur as follows. The motor is normally connected to the load through the gear train that drives the input flange of the MB. Energizing the clutch/brake disconnects the output shaft from the drive and locks its position. The motor then adjusts the follow-up pot to a new position. The clutch/brake is de-energized which reconnects the input flange to the output shaft and releases the brake.

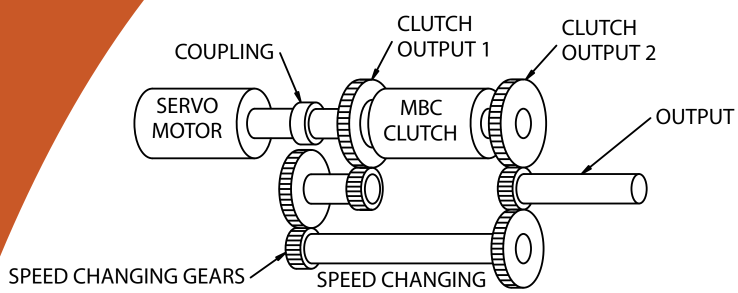


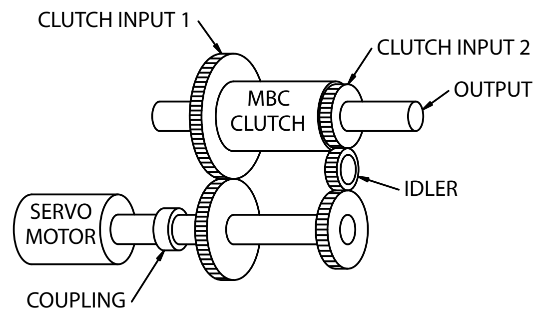
Used to adjust a load

1. Clutch engages, motor drives load to position left or right.
2. Brake engages, holds load.
3. Servo and pot return to neutral.

5. Duplex Clutch (Model MBC)

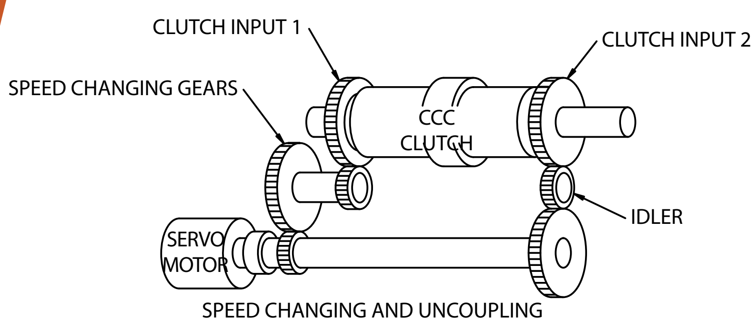
Speed changing without decoupling can be accomplished easily using the MBC duplex clutch. One flange is coupled to the output shaft when the clutch is de-energized; the other flange is free running. Energizing the clutch releases the first flange and couples the second one. The action is analogous to that of a single pole, double throw switch. The MBC can also be used in the same type of operation as a direction changer. The added feature of direction and speed changing can be accomplished by proper selection of mating gears.

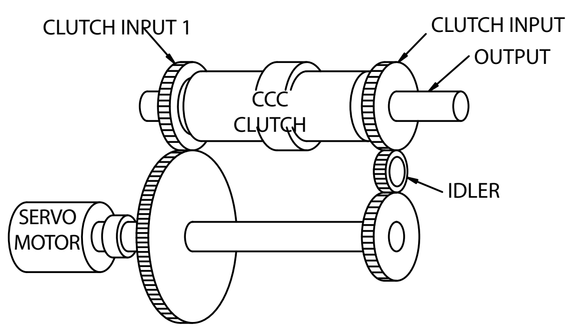




6. Triplex Clutch (Model CCC)

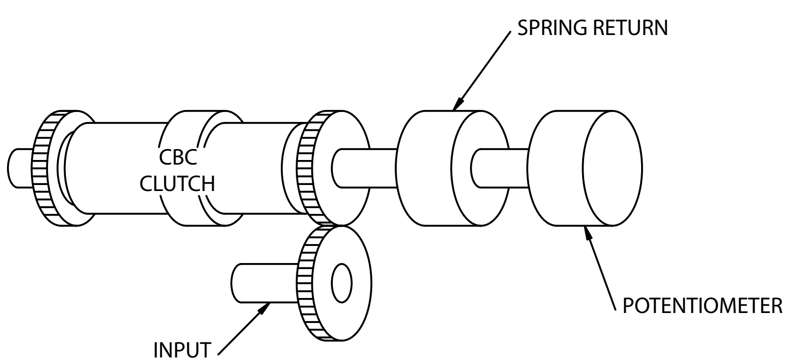
The CCC triplex clutch has many applications in speed changers, direction changers and additive controls. Their use in speed or direction changing is determined by the need for uncoupling in addition to the function desired. Two applications are shown, one as a speed changer and one as direction changer, both with the added feature of uncoupling.





7. Triplex Brake/Clutch (Model CBC)

The triplex brake/clutch has a variety of actions which can all be utilized in operating, holding, and releasing of functions in system applications. Illustrated is an application of the CBC where the clutch is energized to advance the potentiometer to a desired point. The brake is then energized before the clutch is de-energized to hold the potentiometer in position. After the data is obtained from the potentiometer, the brake is de-energized and the potentiometer is returned to zero by the spring return mechanism.



The application of Autotronics' clutches, brakes and clutch/brake combination units to electro-mechanical systems is a relatively simple and straightforward design. There are a few considerations that should be kept in mind in applying these units to your system. These are the principle points of these applications.

1. The friction disc type of electro-magnetic clutch and brake is designed for use as an "on-off" device. Do not attempt proportional control of torque by varying the applied voltage to the coil.
2. The developed torque of these devices is normally in excess of the listed minimum torque shown for each particular model. If modified torque characteristics are desired, consult the factory for their recommendations. Limited torque can be built into these units to meet any requirements. Slip torque and different values of torque are possible in all combination units.
3. Normal operating voltage is 24 to 28 volts D.C. Other coil voltages are available on special order. Operation from A.C. lines is possible by the addition of a simple diode rectifier full wave bridge. This bridge can be built into a unit, in most cases, with a small addition to the overall length of the unit.
4. Mechanical modifications are available on all units at small cost on prototype quantities, and in most cases at no cost on production quantities.

These modifications are:

a) Shaft length to specification (Tolerance on shaft extension ± .020").
b) Gears in place of input flanges (Commercial IV thru Precision IV).
c) Shaft configurations such as milled flats, snap ring grooves, stepped diameters and slots are available.
d) Special end caps to allow coupling to other components; pots, synchros, encoders, resolvers and motors.
e) Integral gear reduction stages built into the housing.
f) Wire leads instead of terminals.
g) Pinion shafts in place of output shaft.