

THE  
**ABC'S**

OF THE TCM

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**SHOWER OF  
SPARKS**



**IGNITION SYSTEM**

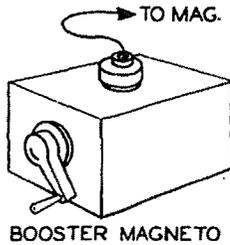
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 **TELEDYNE CONTINENTAL MOTORS**

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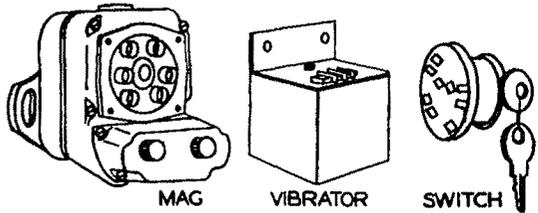
## INTRODUCTION

It's been a long time since the days of the hand-cranked "booster" — in fact you could probably find quite a few of the folks around the field who never heard of it. You used to spin the handle and crank a whole stream of high voltage into the distributor section of the magneto. This got the engine going back in the days of hand-pulled-thru props.



It wasn't long before the industry moved to something better — small aircraft systems employed impulse coupling starting, while the big engines began using vibrator type "boosters".

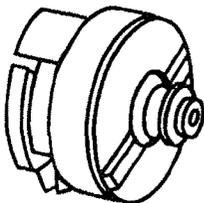
The vibrator-type starting, which has proven so satisfactory on large engines, is now being supplied on TCM S-200, S-1200 and D-3000 series ignition for general aviation aircraft.



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## ABOUT IMPULSE COUPLINGS

Impulse couplings have been used for years on all types of engines. As you know, the purpose of the coupling is:



**IMPULSE COUPLING**

As soon as the engine has started, the impulse feature disengages, and the coupling functions as a plain drive member during normal running.

But impulse couplings sometimes give trouble due to the flyweights becoming magnetized so that they do not engage the stop-pins.

In cold weather the same problem may result from congealed oil on the flyweights.

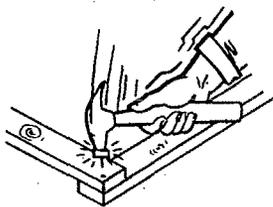
The coupling can produce only one spark for each firing cycle of the cylinder. Under certain adverse conditions of starting it would be better to have a "Shower of Sparks."

1. To "SNAP" the magneto thru its firing position FAST — so it will produce a spark even though the engine is being cranked slowly.
2. To postpone or delay the "SNAP" until the engine piston is near its top center position so that ignition is retarded to prevent a "kick-back".

## The Most Mysterious Part of the Airplane?

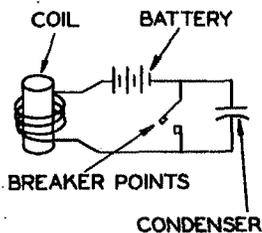
### LET'S REVIEW WHAT WE ALREADY KNOW ABOUT IGNITION!

The high voltage spark of your ignition system is produced by an application of the same principle that makes a halfpound hammer hit a nail with a 200 lb. force.

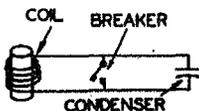
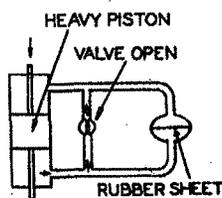


You build up momentum in the swing and then let the nail stop it — on the head.

In the ignition system we build up current in a coil, and then stop it by opening a set of breaker points. On your car, the current is built up by the battery. In a magneto the current is generated in the coil by a rotating magnet. The principle is the same in either case.

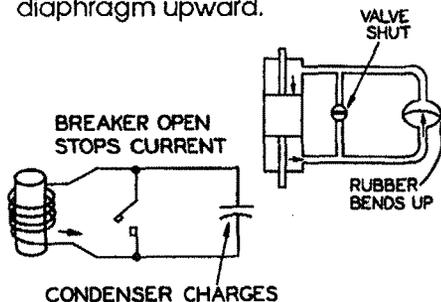


A good analogy of this principle is the action of a heavy piston in a cylinder filled with hydraulic fluid.



Start the heavy piston down the cylinder and slam the valve shut.

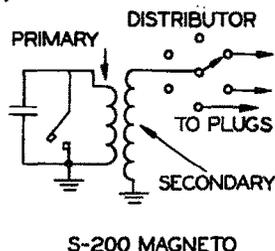
The piston wants to keep moving, and the pressure built up would burst the valve if the fluid did not have another path to travel into the box containing the rubber diaphragm. The momentum of the piston is converted into a force which bends the diaphragm upward.



In the ignition system we use this same idea to generate a surge or "kick" of electrical force — or voltage across the coil. The current in the coil wants to keep flowing — so it builds up voltage across the ends of the coil.

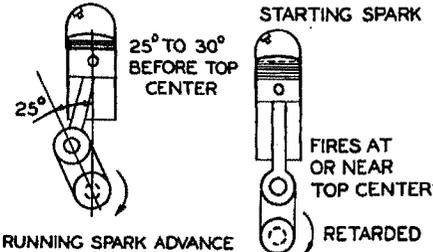
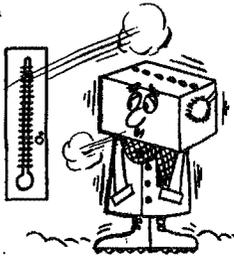
If it were not for the condenser this voltage would burn the breaker points when they open.

This "build-up" surge of voltage can be stepped-up, transformer fashion. On the S-200, S-1200 and D-3000 mags it is stepped up right in the magneto and distributed as high voltage.



# The Theory of the Engine: Here Are Some Facts

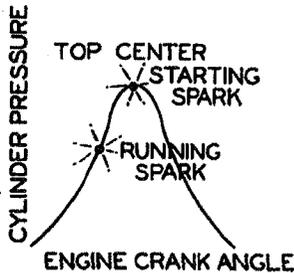
A piston engine has to be cranked — it won't start itself like an electric motor. Worse yet — you can't crank it fast enough with the starter to get the magneto up to sparking speed. That's why booster mags, impulse couplings — or vibrators — are used.



Still worse — spark timing has to be advanced to get full power when the engine is running. But if you tried to start it with this early spark, it would kick backwards and break something. So you must have a retarded or late spark for starting.

The late spark must not be too late, however, or the engine won't pick up speed after it starts to fire.

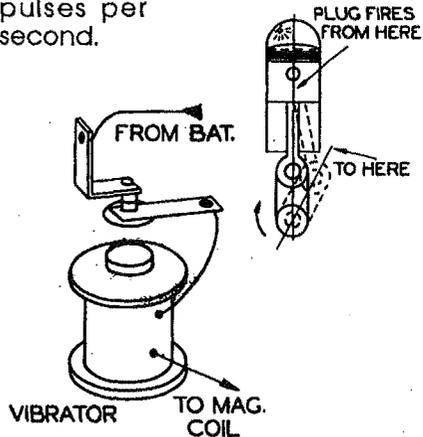
Both starting and running sparks have to be right for the particular engine where the mag is used. To complicate matters further, the retarded starting spark occurs when the cylinder pressure is highest requiring higher voltage.



In cold weather the battery, the oil, the air, and the fuel are all adversely affected. The engine turns harder, the fuel is harder to ignite, and the battery has less power — right when it needs the most.

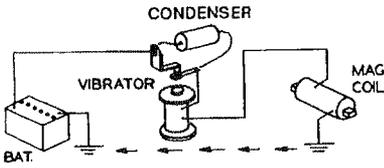
Under these conditions it sometimes needs more than just one spark to get a fire started in the cylinder. The single "one-shot" type of spark delivered by an impulse coupling magneto may not light the poorly mixed gas in the cold cylinder.

By starting at top center, and throwing a continuous stream or "shower" of sparks across the plug — we stand a much better chance of getting the mixture to light and fire the cylinder. The induction vibrator does exactly this. It is a special form of buzzer which provides about 200 pulses per second.



# THE THEORY OF THE CIRCUIT

## TRACING THE "SHOWER OF SPARKS"



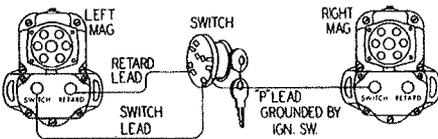
To keep it simple at the start — here's how the vibrator does its job: Current from the battery flows thru the vibrator coil and contacts — and on out thru the magneto coil, completing its return circuit thru the engine and airplane ground.

This does two things:

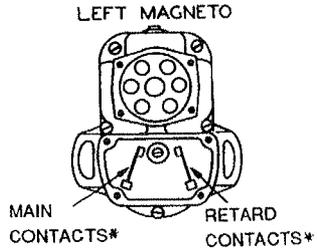
1. sets up a current in the magneto coil.
2. magnetizes the core of the vibrator coil, which pulls the vibrator contacts apart.

When the vibrator contacts break the circuit, the current is brought to a sudden stop, producing the required voltage surge in the magneto coil for ignition purposes. The condenser prevents excessive arcing of the vibrator contacts.

In most systems only the LEFT magneto is boosted for starting. The right magneto is automatically grounded to prevent possible advance ignition and engine "kick-back."



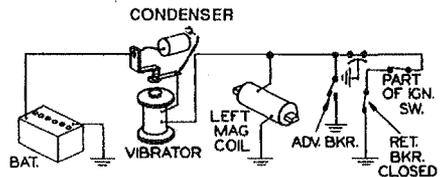
To get a retarded or late spark for starting, the LEFT mag has two contact assemblies in it. You time the mag to the engine by the "ADVANCE" or "MAIN" contacts. The "RETARD" or "START" contacts open a certain number of engine degrees after the main, or "advance" contacts open, depending on engine requirements.



\* Main and Retard Breakers may be reversed due to magneto rotation.

There is a set of contacts in the ignition switch that connects the retard contacts and the main contacts together during starting. As long as either of the contacts are closed, the magneto coil will be short-circuited to ground and cannot produce ignition voltage. Thus the vibrator cannot produce a spark until the retard contacts open.

When the engine starts the switch is released and automatically returns to the "BOTH" position. This disconnects the retard contacts, the vibrator and the starter from the circuit, and removes the ground from the RIGHT magneto.



## **HOW WAS THAT AGAIN?**

### **LET'S LOOK AT THAT CIRCUIT IN MORE DETAIL**

(1) Starting with the aircraft parked, the engine dead and the switches OFF, you have a circuit that looks like this. NO ACTION in this picture at all — just two mags grounded out though the ignition switch.

(2) Move the switch to "START" and a whole lot of things happen.

- a. The starter solenoid is energized.
- b. The vibrator is connected to both sets of contacts in the "L" mag.
- c. The "R" mag still is grounded out through the switch
- d. The vibrator starts vibrating and sending current pulses into the "L" mag, but since both contacts are closed, these pulses are grounded out.
- e. The engine is being turned toward firing position by the starter.
- f. The red lines in this picture shows the current path.

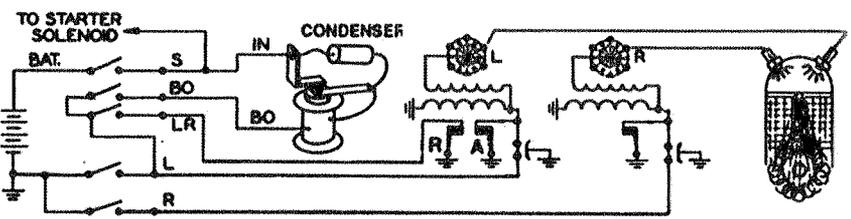
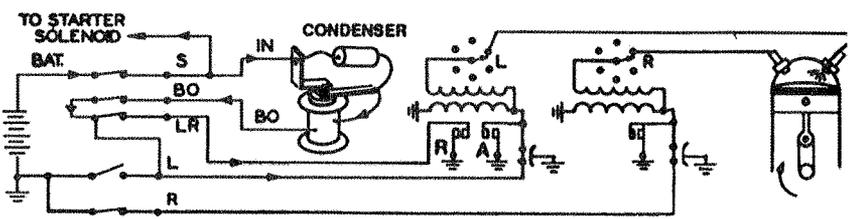
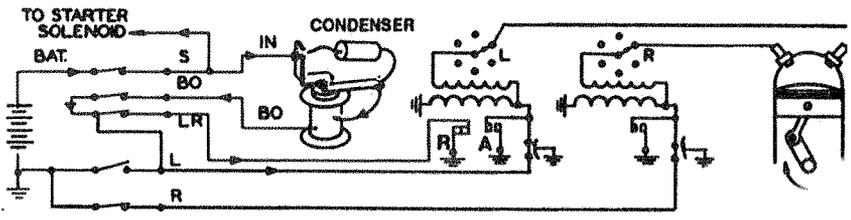
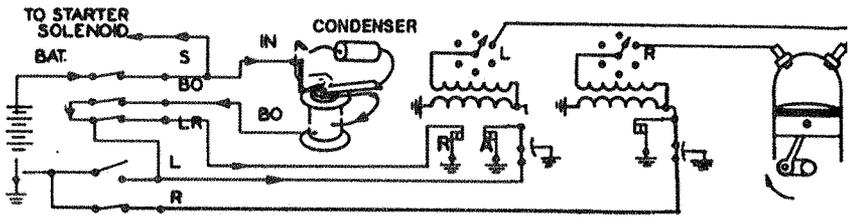
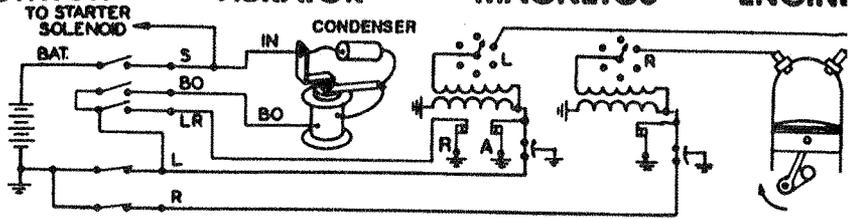
(3) When the engine has turned to it's full advance firing position, the advance contacts in the "L" mag open — However, the retard contacts are still closed — so the current pulses from the vibrator are still grounded out. The "R" mag is of course still grounded out through the switch — So we still get no spark at either plug.

(4) When the engine has turned to approximately TOP CENTER position, the retard contacts open. Now, the vibrator pulses are no longer grounded by either set of contacts. The current pulses pass thorough the primary of the "L" magneto and induce a voltage in the secondary, which is transmitted through the distributor and fires the spark plug. The engine will continue to fire in the retarded position as long as the switch is held in "START".

(5) When the switch is released to the "BOTH" position, the circuit changes to the picture shown here.

- a. Both mags fire at full advance firing position.
- b. The vibrator is disconnected.
- c. The starter is disconnected.
- d. Both plugs fire.

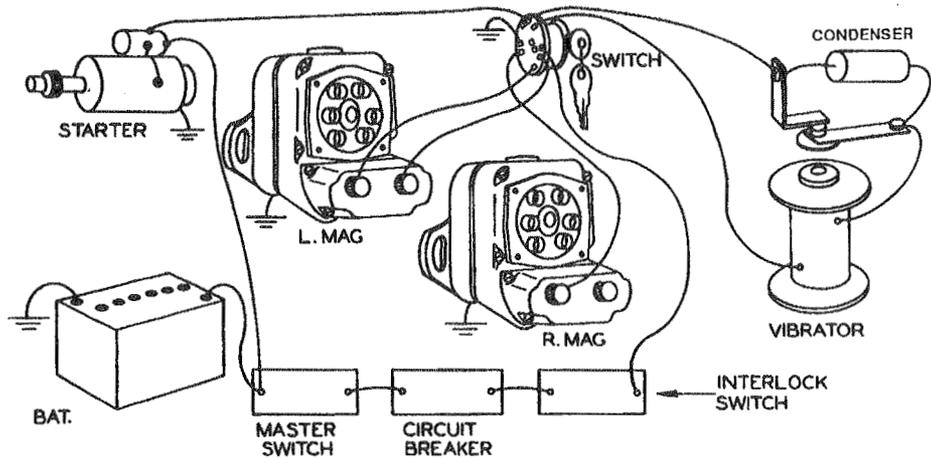
**SWITCH                      VIBRATOR                      MAGNETOS                      ENGINE**



**R—Retard Breaker      A—Advance Breaker**

## MEANTIME —

*Back at the maintenance hanger.*



## TROUBLE SHOOTING INVOLVES THE WHOLE SYSTEM!

If you have a problem, keep this list in mind: The vibrator can't do its job unless:

- It has enough input voltage.
- The retard and advance contacts are BOTH correctly timed.
- The magnetos are correctly timed to the engine.
- The vibrator is correctly adjusted internally.

Grab the airframe manual and trace out the circuit that feeds the vibrator battery current. There may be several components such as circuit-breakers, switches, interlocks, etc. which could lower the input voltage.

Unless you have good clean connections all through the circuit, the current may not get to the magneto.

Listen to the vibrator buzz while cranking the engine. The tone should change as the magneto breakers open and close.

If no buzzing is heard, check the voltage at the "IN" terminal of the vibrator while cranking. Voltage must be at least 8 volts on a 12 volt System or 13 volts on a 24 volt System.

If the tone doesn't change, check out the wiring to the magneto — also the contact springs in the magneto breaker cover.

## MORE ON Trouble-Shooting

If the RETARD contacts don't open, you'll get no spark at all — and no start!

If these contacts don't close, you'll be cranking with a fully advanced boosted spark and may get a kick-back. This would also result if the wire to the RETARD contacts was broken, or had a poor connection at the mag.

If the RETARD contacts open too late, the engine may fire but not pick up speed and run. Check your timing!

If the wire to the ADVANCE contacts is broken — or has a poor connection at the mag you'll not only have a permanently "HOT" mag, you will have no way for vibrator current to get into the mag and fire it. The tip-off to this condition would be in the sound of the vibrator — instead of changing tone you would hear the vibrator stop and start as the engine is being cranked over. It is a good idea to investigate the magneto connections — both ADVANCE and RETARD whenever difficulty is experienced. If you can't feel the terminal compress the contact spring in the S-200 or D-3000 magneto slightly you may not be getting good contact. Look at the contact springs in the mag with a flashlight. If they are dirty or burned this may be your trouble.



## ANOTHER "LOW BATTERY" TRICK —

If the battery can be made to rock the engine over compression you can boost the vibrator input voltage by connecting a few flashlight cells in series with the "IN" terminal of the vibrator. The vibrator current is only a few amperes and dry cells can supply this while you rock the engine over with the starter.

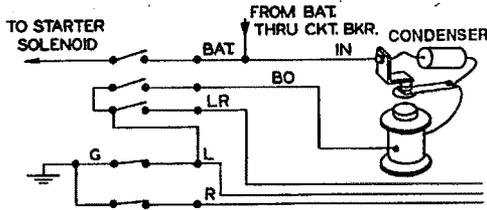
Certain aircraft incorporate a toggle switch on the instrument panel marked, "Starter —ON-OFF. Moving this switch to the "OFF" position disconnects the starter and allows the engine to be hand propped while the Ignition Starter switch is held in the "START" position to energize the booster.

### Remember:

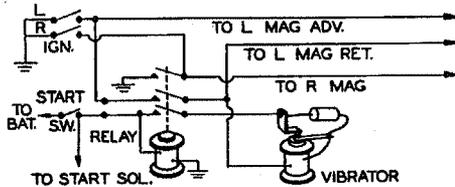
- (1) Check the Mag internal timing as per magneto manual.
- (2) Check the mag-to-engine timing as per the engine manufacturers handbook.

## VARIATIONS IN AIRFRAME CIRCUITS

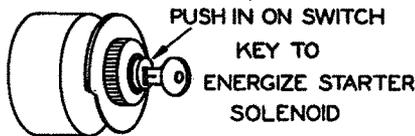
The circuit on Page 6 is the one most commonly used. But some airframes use variations. On some two-engine ships you may find the "IN" terminal of the vibrator connected directly to the battery bus (usually through a circuit breaker). This enables the same vibrator to serve both engines and has a further advantage in that full battery voltage always gets to the vibrator without going through long lengths of wiring.



On some helicopters, the vibrator incorporates a relay to provide for the use of a simple ON-OFF starter switch on the control stick. This is usually connected in series with the interlock switch for the throttle. This system employs standard ignition switches. The same type circuit may also be found in fixed wing ships which retain the conventional ignition switch.



Some switches are made with a "PUSH-TO-START" feature, which inhibits accidental starter engagement.



## Ignition Switch And Starting Vibrator Reference Charts

<b>Ignition and Starting Switches</b>		
<b>Part Number</b>	<b>Description</b>	<b>Dial - Order Separately</b>
10-357200-1	Key, Twist/Start	10-126676
10-357210-1	Key, Push/Start	10-187468
10-357230-1	Lever, Twist/Start	10-126676
10-357240-1	Lever, Push/Start	10-187468
10-357290-1	Key, No Start Function*	Dial Included
<b>Starting Vibrators</b>		
<b>Part Number</b>	<b>Description</b>	<b>Used With Ignition System</b>
10-176487-121	12VDC	S-200
10-357487-241	24VDC	S-200
10-176487-122	12VDC	S-1200
10-357487-242	24VDC	S-1200
10-382775-12	12VDC	D-2200, D-3200
10-382808-24	24VDC	D-2200, D-3200
10-176485-121	12VDC W/Relay*	S-200
10-176485-241	24VDC W/Relay*	S-200
10-176485-122	12VDC W/Relay*	S-1200
10-176485-242	24VDC W/Relay*	S-1200
10-382780-12	12VDC W/Relay*	D-2200, D-3200
10-382780-24	24VDC W/Relay*	D-2200, D-3200

\* When using other than TCM Combined Ignition and Starting Switches, use Starting Vibrators with relay. Consult Airframe Parts Catalog for Ignition Switch and Starting Vibrator application.

## HELP ??

This booklet has been prepared to help you understand some of the features of S-200, S-1200 and D-3000 ignition systems by TCM. We hope it sheds some light on the problems which you, as an operator, often encounter with a new and unfamiliar piece of gear. If you have any questions not covered here, you should write to:

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