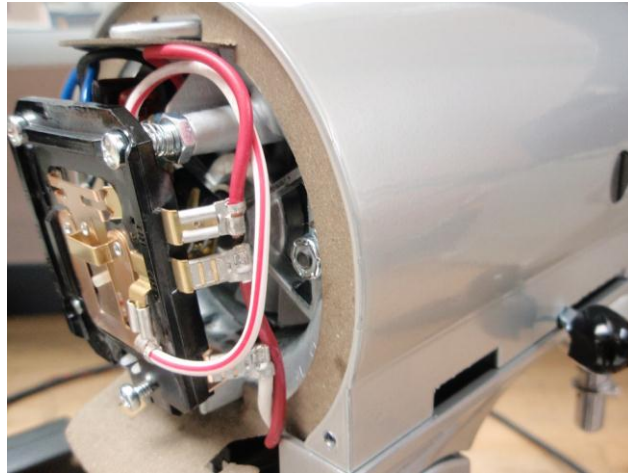


KitchenAid®

Classic Stand Mixer



Speed Control

Theory of Operation

And

Troubleshooting Guide

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Classic Stand Mixer Speed Control
Theory of Operation and Troubleshooting Guide

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Theory of Operation

The KitchenAid Classic Stand Mixer speed control mechanism is an electro-mechanical system comprised of (4) components; the governor, the speed lever (including the speed link and cam assembly), the control board and the phase control circuit. Electro-mechanical means that the control system takes the rotational speed of the armature (mechanical) and uses it to determine the control voltage (electro) to send to the mixer motor.

To understand how the complete system works, it is best to first understand what the basic function of each component is. The following sections will cover the functions of each component.

The Governor

The job of the governor is to take the rotational speed (spin) of the motor's armature and convert it to a linear (straight line, back-and-forth) motion (see Illustration 1).

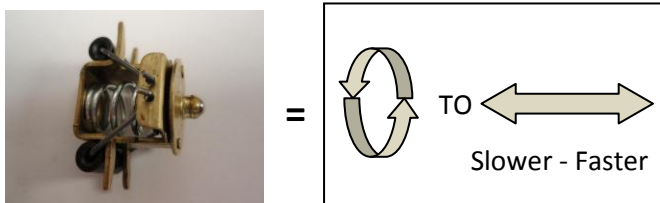


Illustration 1

It does this through the use of the weight arms whose ends are fastened to the governor flange. The flange is held at a fixed location on the armature shaft by the governor pin. As the motor spins, the weight arms are moved outward in an arcing motion by centrifugal force. It is this outward arcing motion of the weight arms that push the governor yoke backward (see Diagram 1 in Appendix A). When the motor is slowing down, the motion of the weight arms and yoke are forward (see Illustration 1). The ball plate of the governor is fastened to the governor yoke so that it also moves with the yoke. When the motor is not running (OFF) the governor ball plate is at its farthest forward position and when the motor is running at full speed the governor ball plate is at its farthest back position. This linear motion of the governor yoke/ball (forward and backward) is what the speed control board uses to do its part. As we'll see later, the control board uses switches to determine the output of the phase control to the motor field (stator).

The Phase Control

There is no need to go into a detailed theory of operation on the electrical workings within the phase control circuit. All that is needed to know is that the phase control will supply one of three different voltages to the motor stator (field) windings of the motor. These voltages are determined by the opening and closing of the w-bar switches on the control board. We will get into how these switches work in the next section. The voltages that the phase control produces are roughly 40 volts (AC), 80 volts (AC) and 120 volts (AC). These voltages are not exact but are presented here as even round numbers for the sake of explanation. Leaving the electrical description at that, let's just say that ideally the phase

control will maintain the voltage going to the stator at 80 volts (AC). It does this by “reading” the state of the w-bar switches. We will call these switches W1 (BLUE) and W2 (GREEN) in the next section.

The Control Board

The control board is a moveable plate with 3 contact switches on it. One of the switches is used to power the mixer ON and OFF. The power switch is made up of the two point contacts (fixed point and moveable blade) at the bottom of the control board. The black cord lead is attached to the stationary point on the control board. The power switch is normally open when the mixer is in the OFF position. Whenever the speed control lever is moved from OFF to speed STIR or any of the other ON positions, the speed link cam (white plastic piece on the end of the speed link) will allow the points to close energizing the motor through the moveable blade to one side of the stator field windings (white lead wire). The white power cord lead is connected through the phase control and control board (via the w-bar points) to the other side of the stator field windings (red lead wire).

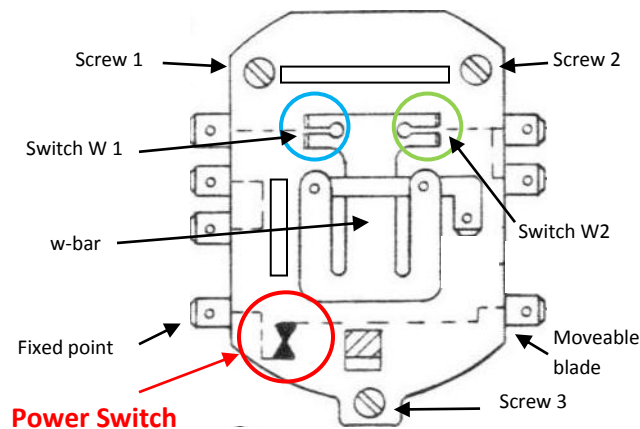


Fig. 1) Control Board parts (as viewed from the rear)

Table 1

Switch condition	W1	W2	AC Voltage
1	CLOSED	CLOSED	120
2	OPEN	CLOSED	80
3	OPEN	OPEN	40
4	CLOSED	OPEN	INVALID (see note below table)

Note: Condition 4 is invalid as the control board is designed such that W1 always opens first (see illustration on switch skew on the next page).

With the mixer in the OFF position both w-bar switches (W1 and W2) will be closed. As you can see in Table 1, that represents a 120 volt AC condition, however the voltage will not be sent to the motor stator windings because the power switch will be open. Now, recall from the section on the governor that it is going to move (backward) toward the w-bar as the mixer speeds up and (forward) away from the w-bar as the mixer slows down. It is this forward and backward (linear) action that cause the w-bar switches W1 and W2 to open and close. Also recall that the phase control will try to maintain the voltage at 80 volts AC (condition 2 in Table 1). When the speed control lever is moved to a lower speed, the condition of the switches will go from condition 2 to 3 (switch W1 and W2 both open). When this happens, the phase control will send 40 volts to the stator to slow the armature rotation down reducing the speed of the mixer until the 80 volts (condition 2) is once again achieved.

This will also happen when more torque is needed as the mixer will slow down under a heavy load.

When the speed control lever is moved to a higher speed, switch W1 will close (condition 1) and the phase control will send 120 volts to the stator to increase the rotational speed of the armature.

The w-bar points are skewed (see Fig. 2) in such a way as to force switch W1 to always open before switch W2 to maintain the proper operation of the speed control as represented in Table 1.

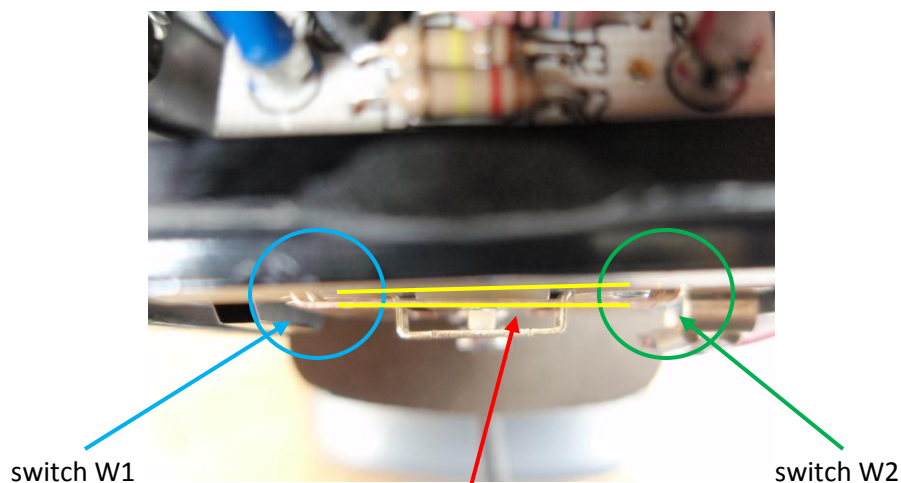


Fig. 2) Control Board w-bar switch point skew

Figure 2 shows how a properly assembled control board should look like from the top. The upper yellow line in between the two circles represents the plane of the control board and the lower yellow line represents the plane of the w-bar switches. As you can see, switch W1 is closer to the plane of the control board than switch W2 (see the gap distance between the ends of the yellow lines). This will always facilitate the opening of switch W1 first. “Points jumping” happens when the skew of the two switches is nearly identical or so close that condition 2 in the table is skipped over (both switches open and close simultaneously) and the phase control the jumps between 40 volts and 120 volts while unsuccessfully trying to set condition 2 (80 volts).

The screws on the control board (see Fig. 1) are used to set the desired speeds of the stand mixer. The screw adjustment will move the control board closer to or farther away from the governor ball. The end result is that when the screws are adjusted properly, the distance the governor has to move to contact the w-bar points is fixed and the speeds are set. The speed setting screws 1 & 2 (see Fig. 1) at the top of the control board must be adjusted to approximately the same distance (level - nut to nut & screw head to screw head), because if they aren’t it has an effect on the skew of the control board w-bar switches (see Fig. 2). This could cause the w-bar switches to operate improperly resulting in points jumping. Screw 3 is used to set the mixer speed 2 rpm. The screws are currently adjusted to the following speed settings:

Speed STIR – adjust screws 1 & 2 for a hub rotational speed of 43 to 50 rpm.

Speed 2 – adjust screw 3 for a hub rotational speed of 56 to 64 rpm.

The Switch Lever, Speed link and cam

Once the speeds are locked in by the setting of the control board screws, the only thing left that should have any effect on the mixer speeds is the Switch Lever, Speed Link & cam assembly. This assembly has a two-fold function.

First, when moved from the OFF position to STIR it moves the link and cam (white plastic piece) backward into the square opening on the control board underneath the moveable blade. The cam has a slope on the front edge that when moved into the control board opening, allows the moveable blade of the power switch to drop down onto the fixed point applying power to the stand mixer (speed STIR). When this happens, the governor weight arms will move the governor yoke and ball backward until w-bar switch W1 opens and condition 2 (80volts) in Table 1 is satisfied.

Second, as the speeds above speed STIR are selected, the speed link along with screw 3 (see Fig. 1) will moves the control board closer to or farther away from the governor directly affecting the distance that the governor has to travel to open or close the w-bar switches to again satisfy condition 2 (Table 1). Remember that the linear motion of the governor yoke/ball plate is changed as the motor speeds up or slows down. For example, when the mixer switch is moved from speed 2 to speed 4, the link/cam assembly will move the control board backward lifting it away from the governor ball. This lifting causes both of the w-bar switches to close (condition 1) until the governor ball again comes into contact with the w-bar opening switch W1 (condition 2).

If the speed adjustment screws are set properly, speed 8 will still have the governor ball in contact with the w-bar pad and the phase will still maintain the ideal 80 volts to the stator field (see Table 1 – condition 2). However, once the switch lever is moved from speed 8 to speed 10 the control board should lift off of the governor ball to a position where the w-bar points will both remain closed (governor fully backward does not contact the w-bar). The end result is that the phase control continues to send the full 120 volts to the motor and it runs at maximum speed (speed 10).

Ideally, w-bar switch W1 will only close as higher speeds are selected (speed selector) or more torque is needed, and w-bar switch W2 will only open as lower speeds are selected (speed selector).

Troubleshooting (refer to the section on Theory of Operation and Appendix A)

Applying the knowledge gained in the section on theory of operation will make the job of troubleshooting any control issue a little easier. With the mixer end cover removed, take a quick look for some of the more obvious issues (control screws not adjusted properly, governor not seated on the pin, bent w-bar or point skew missing, etc.) that can cause mixer speed problems. Let's take a look at some common speed control issues.

No Torque

First of all it is necessary to understand where torque comes from. Torque is obtained by the closing of w-bar switch W1. The phase control will then supply 120 volts AC to the mixer motor to increase the speed of the armature thus creating the torque. The load applied at the planetary shaft has the effect of slowing the mixer motor down. As the motor slows down, the governor will move forward (away from the control board) allowing the w-bar switch point W1 to close. The phase control will send 120 volts AC to the motor (see Table 1) to increase the torque. If there is no torque, the w-bar switch W1 must not be closing all the way. This can be checked easily by holding the planetary shaft still (mixer humming on speed STIR – no torque) and then using an insulated tool, lightly tap the w-bar in between the two switches (W1 & W2) such that switch W1 momentarily closes. When this happens the phase control sends 120 volts to the motor and the planetary will again rotate (torque).

At this point it would be easy to assume that the control board is defective as w-bar switch W1 is part of the control board. The fact is though that there are several parts of the system that can affect the opening and closing of switch W1. With practice and the above knowledge you will learn to quickly identify them:

1. Control Board
 - a. Do the w-bar switches have the proper skew (see Control board description)?
 - b. Is the w-bar damaged or bent?
 - c. Are the two top screws (W1 & W2) adjusted evenly?
 - d. Are they adjusted too far in (against the governor)?
2. Governor
 - a. Is the governor seated properly on the governor pin (governor location)?
 - b. Has the armature shaft moved backward (loctite loose)?
 - c. Is the governor assembled improperly (weight arms tight or bent, ball plate loose, etc.)?
 - d. Is the governor catching (hanging up) on the armature shaft
(This could be due to a bent or warped governor yoke, a burr, a nick, or flashing on either the governor yoke or the armature shaft)

No one situation should be considered separately as one may have contributed to another (multiple defects). For instance, a poorly assembled governor may cause the person setting speeds to overcompensate for the defect by improperly adjusting the speed setting screws. If the screws are adjusted in too far the governor ball will be in contact with the w-bar even when the unit is in the OFF position. If the governor is already in contact with the w-bar (switch W1 open) in the OFF position, switch W1 will never be able to close when the unit is running as the governor moves even farther back while it is rotating.

No Speed Change (STIR to 2)

This is typically caused by an improper adjustment of the control board screws. When the speed control lever is moved from the speed STIR position to the speed 2 position the control board has to move away from the governor to allow w-bar switch W1 to close which in turn causes the mixer to speed up (to speed 2) until switch W1 opens again and the phase holds the voltage at ~80 volts AC. This

happens when the lower screw (screw 3) hits the vertical edge of the speed link. If the screw does not come in contact with the link when speed 2 is selected, it won't push the control board back enough to affect the speeds (w-bar point W1 closes). The end result is that there will not be any speed change from speed STIR to speed 2.

No Speed Change (8 to 10)

There are several things that can lead to no speed change from speed 8 to speed 10. The most obvious (based on the theory of operation) would be that the control board, when moved by the speed link/cam, is not moving back far enough to allow w-bar switch W1 to close sending the full 120 volts AC to the motor windings. This could be due to an improper setting of any or all of the speed setting screws. It could also be due to an armature that has moved backward (loctite set with armature not fully seated). An easy way to check for an open w-bar switch (W1) on speed 10 is to use an insulated tool to lightly push in on the top of the w-bar (between the switch points W1 & W2) while the mixer is running. If the speed increases, that means that switch W1 was not fully closed and the motor was not getting the full 120 volts.

Another thing that will affect the speed change from speed 8 to speed 10 is if the mixers voltage source is too low. If the voltage source (production line voltage) would drop to let's say 113 volts instead of the ideal 120 volts, there may not be enough voltage to effect a noticeable increase in motor speed (from 8 to 10) even if the w-bar switch W1 has closed.

Another thing that can keep the mixer from changing speeds from speed 8 to speed 10 is poor alignment of the vertical center shaft. If the upper and lower center shaft bearings in the housings are not aligned properly, it can cause a binding such that the motor cannot rotate fast enough to achieve the rpm's required for speed 10. This can also happen if the motor is tight (usually caused by a tight rear armature bearing – bearing bracket).

Points “jumping”

This condition was addressed in the description about the function of the Control Board in the section on the Theory of Operation. It is caused by either a faulty control board w-bar (points not skewed properly) or improper adjustment of the speed setting screws 1 & 2 (see Fig. 1 & Fig. 2 on pgs. 2 & 3 and the section on The Control Board Theory of Operation).

Mixer Does Not Shut Off

There are a couple of situations that can cause the stand mixer to stay in an 'ON' state even though the switch lever has been moved to the 'OFF' position.

1. The power switch points are not opening wide enough. This is usually caused by a bent or damaged (control board) moveable blade or a stationary point that is pushed up too far.
2. The control board flag (on the black cord wire connector) might have been bent in during assembly. The black cord wire flag will come into contact with the moveable blade while the mixer is in the 'OFF' position causing a completed circuit. The effect is the same as closing the power switch points using the speed select lever (turning the mixer ON).

Mixer Does Not Turn On

There are several things that could cause the mixer to not run at all. As far as speed control related issues are concerned, the most likely cause would be that the power switch points are not fully closed so that power is not supplied to the motor stator windings through the moveable blade on the control board. This is most likely due to a misassembled control board or bent or damaged power switch contact points. Another part of the speed control system that could cause a mixer to not run would be a bad phase control board.

Outside of the speed control circuitry there are a few other things that could cause a no run situation. If the brushes are missing or improperly inserted into the brush holders, it may be that they are not coming into contact with the armature commutator. Non-conducting debris in between the brush and commutator will have the same effect. A dead mixer motor could also be caused by an open circuit (broken or loose wire). A short in the mixer can trip a circuit breaker causing a loss of power at the power outlet. Check to be certain that the necessary power is available at the outlet and that the mixer is plugged in.

Mixer Only Runs Fast (cannot adjust)

or

Mixer Only Runs Slow (cannot adjust)

These two conditions are usually an indication that something is wrong with the phase control circuit. Replacing the phase control circuit board on the stand mixer is the easiest way to determine if it is causing the problem. A higher than normal source voltage can also cause the mixer to run too fast for the phase control circuit to take control of the speeds (i.e. armature rotation is so fast that w-bar switch points W1 and W2 remain open).

Appendix A

(circuit diagrams – 115 v. domestic)

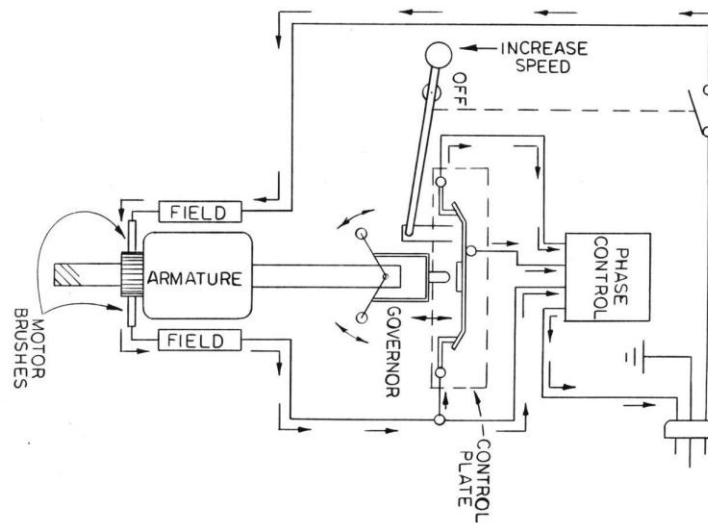


Diagram 1

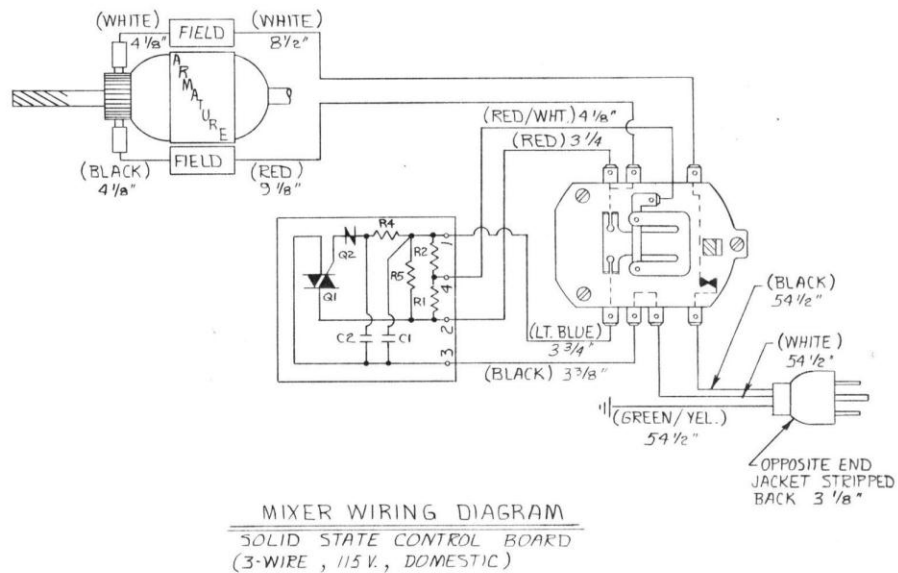


Diagram 2