Warner Instruments
Dual-Dipole Stirplate
Model Spin-2

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CE

Table of Contents

The Warner **Spin-2** Bilayer Stirplate is a unique device designed to allow the simultaneous stirring of two solutions, one on each side of a bilayer membrane.

The unit incorporates two counter-rotating dipoles and the phase angle between the dipoles is digitally controlled to minimize the influence of a time-varying magnetic flux on the headstage circuitry.

In addition, the electronics and mechanical components are well shielded. The unit sports an external controller which allows the user to adjust the rotation speed without opening the Faraday cage. The mechanical components are designed to present virtually no vibration to the bilayer chamber.

The result is a quiet and versatile device that can allow the recording of electrophysiological signals while stirring.

Features of the **Spin-2** include:

- ✓ Dedicated design for bilayer applications
- ✓ Independent *cis*/*trans* dipoles
- ✓ Minimized magnetic flux at bilayer membrane
- ✓ Steel side panels for attachment of magnetic components
- ✓ Liquid crystal magnet positioning indicator
- ✓ Vibration free operation
- ✓ External, isolated controller
- ✓ Rack mount controller available

THIS EQUIPMENT IS NOT DESIGNED NOR INTENDED FOR USE ON HUMAN SUBJECTS

NOMENCLATURE

Text conventions

To minimize the potential for confusion, we have employed several text conventions which are specified below. Since our goal is to provide clarity rather than complexity, we welcome any feedback you may wish to provide.

- Warner Instrument product numbers are presented using **bold type**.
- References to separate components controls are specified using UNDERLINED SMALL CAPS.
- References to specific controls are specified using NON-UNDERLINED SMALL CAPS.
- References to control settings are specified in *italic type*.
- Special comments and warnings are presented in highlighted text.

Any other formatting should be apparent from context.

INTRODUCTION

Stirring of solutions in a bilayer cup and chamber has traditionally been achieved using either a commercial stirplate or a home-made device. Unfortunately, commercial stirplates are not designed for use in a bilayer rig and home-made devices can be inadequate due to the limited engineering resources often available in a biochemistry lab. In either case, the most common design for the resulting stirplate is that of a *single rotating magnetic dipole* being presented to the bilayer chamber.

A result of this approach is that the chamber must be repositioned if the stirbar is moved from the *cis* or *trans* well to the other side. More importantly, it is virtually impossible to simultaneously stir both wells since the respective stirbars will be drawn to the common rotational axis defined by the stirplate magnet. The resulting collisions between stirbars and the bilayer cup introduces a large noise artefact into the acquired data.

A second obstacle is associated with the interaction of a rotating magnetic dipole with the headstage circuitry. The time-varying magnetic flux through this closed loop generates an electromotive force resulting in the appearance of a sinusoidal current artefact in the data.

Many researchers avoid these problems by not stirring while recording, which is often undesirable. The **Spin-2** has been specifically designed to address these difficulties and is the only apparatus commercially available to provide an integrated solution to these issues.

Several design strategies have been implemented in the **Spin-2**. Most notable is the presence of dual rotating dipoles, one each for the *cis* and *trans* wells. This approach allows the stirbar within each well to be independently manipulated which abolishes cup/stirbar collisions. The relative separation between dipoles is adjustable allowing the apparatus to be used with bilayer cups and chambers of various sizes.

Second, the rotation (phase and speed) of the two spinning dipoles is digitally controlled. This approach allows the **Spin-2** to present the smallest possible magnetic flux to the bilayer membrane resulting in a reduced induction current in the headstage circuit. A liquid crystal display on the top of the stirplate allows the researcher to view the rotating dipoles in real-time.

Third, the mechanical assembly is very quiet. This feature introduces the possibility of placing the bilayer chamber directly onto the stirplate during use. Most researchers currently place their chambers on an independent support stage which de-couples the chamber from the mechanically noisy stirring mechanism. The magnetic strength of the **Spin-2** dipoles permits the use of either strategy to minimize noise in their setup.

Finally, the apparatus is electrically isolated and well shielded, allowing the rotation speed controller to remain outside of the Faraday cage during use.

CONTROL DESCRIPTION

The **Spin-2** has two control points: A DIPOLE POSITIONING KNOB on the front of the STIRPLATE, used to adjust the relative separation of the dipoles, and an external CONTROLLER.

Spin-2 Controller

The **Spin-2** CONTROLLER, pictured to the right, is an external device used to power the STIRPLATE and to adjust the rotation speed of the dipoles.

Front panel

The CONTROLLER front panel has an ON/OFF SWITCH, a ROTATION SPEED INDICATOR, and a SPEED ADJUSTMENT KNOB.

The ON/OFF SWITCH powers the stirring mechanism in the associated STIRPLATE.

SPEED ADJUSTMENT is via a continuously variable knob used to set the rotation speed of the dipoles in the STIRPLATE. *Slow* and *fast* speed positions are indicated.

A GREEN LED indicates power *on* status as well as the relative rotational speed of the dipoles. The faster the rotational speed, the more rapidly the LED *blinks*.

Rear panel

Several attachment points are located on the rear of the control unit. These include a 6-pin DIN connector for connecting the STIRPLATE to the CONTROLLER, a green grounding plug and a power input jack.

Stirplate

Front panel

The stirplate has a single control located on the front panel, used to adjust the relative separation between the rotating dipoles. Minimum separation is 0.4 in.

Top panel

The top panel has a liquid crystal window to reveal the position and rotation of the magnets. Two steel strips are located on either side of the liquid window (under the overlay) for attachment of magnetic supports.

SETUP

Stand-alone setup

1. Remove the **red shipping screw** from the bottom of the STIRPLATE prior to use.
2. Place the **Spin-2** CONTROLLER in a convenient location near your setup. Do not place it inside the Faraday cage.
3. Place the STIRPLATE within your Faraday cage and route the attached connector cable to the CONTROLLER. The cable carries its own internal shielding and so no additional steps need be taken to shield the unit.
4. Connect the two units by attaching the 5-pin DIN connector to the rear of the CONTROLLER.
5. Complete the ground circuit by connecting the CONTROLLER GROUND (the green banana jack on the rear panel) to your amplifier or cage ground (otherwise known as the setup *common ground*)
6. Plug the power supply into a convenient outlet.

The **Spin-2** is now ready to use.

Rack mount setup (SunStir setup)

1. Remove the **red shipping screw** from the bottom of the STIRPLATE prior to use.
2. Place the **Sun*Stir*** RACK MOUNT CONTROLLER into your rack.
3. Place the STIRPLATE within your Faraday cage and route the attached connector cable to the CONTROLLER. The cable carries its own internal shielding and so no additional steps need be taken to shield the unit.
4. Connect the STIRPLATE to the CONTROLLER by attaching the 5-pin DIN connector to the rear of the CONTROLLER.
5. If using the **Sun-1** Halogen lamp, make a similar connection from the lamp to the rear of the CONTROLLER.
6. Complete the ground circuit by connecting the CONTROLLER GROUND (the green banana jack on the rear panel) to your amplifier or cage ground (otherwise known as the setup *common ground*)
7. Plug the **Sun*Stir*** into a convenient outlet.

The **Spin-2** is now ready to use.

OPERATION

The **Spin-2** stirplate contains two rotating dipoles. One dipole is positionally fixed relative to the stirplate case while the other is adjustable using the POSITION ADJUST control. We will refer to the fixed dipole as the front dipole and the adjustable dipole as the rear dipole. The general setup procedure is to first orient one well in the bilayer chamber to the front dipole and then to 'dial in' the rear dipole to the other well.

In general, a mechanical noise artefact is usually generated by collisions between a rotating stirbar and the cup. Since the **Spin-2** is designed to independently control two stirbars (one in each well), it is critical that all stirbars are optimally centered within their respective wells.

1. Begin by assembling your cup and chamber. Apply lipids, add solutions and agar bridges.
2. Place a single stirbar into the chamber's front well and place the chamber on top of the stirplate.
3. Turn the stirplate *on* and position the chamber so that the stirbar rotates quietly within the well and on top of the front dipole. (Move the rear dipole away from the front dipole if needed.)
4. Now, without moving the chamber, place a second stirbar into the rear well and begin moving the rear dipole into position.
5. Continue to adjust the position of the rear dipole until the rear stirbar rotates quietly on top of the rear dipole.

   NOTES: You may also need to adjust the side-to-side position of the rear well to find the optimal well/dipole position. Do this by rotating the chamber about an axis defined by the front dipole/front well pair. Take care to not disturb the position of this pair !

6. Once the magnets within both wells have been positioned, turn the stirplate off, insert your electrodes and continue with membrane formation.

   NOTE: In the event that the chamber is moved during membrane formation, simply reposition the chamber over the dipoles without re-adjusting the position of the dipoles. In addition, we have included a small rubber mat which can be used to further secure the position of the chamber on top of the stirplate. Place the mat under the chamber before centering the first stirbar.

7. Check for mechanical artefacts by turning *on* the **Spin-2** once a stable membrane is formed. Make final positional adjustments as necessary.

THEORETICAL CONSIDERATIONS

Sources

In a bilayer stirplate there are three possible sources of noise: electrical, mechanical and magnetic. Electric sources include the motor used to drive the rotation of the dipoles and the power/control wires entering the Faraday cage. Mechanical sources include the mechanism providing the rotation to the dipoles and collisions between the stirbars and the chamber. The interaction of the rotating magnetic field with the headstage electrodes represents the primary magnetic noise source in a stirplate.

Electrical noise

Electric noise sources are well controlled in the **Spin-2**. The stirplate enclosure, as well as the associated connecting cable, are internally shielded which effectively makes the inside of the stirplate topologically outside the Faraday cage. In addition, the drive motors are of the dual bearing, DC type which provides for very quiet operation. This approach allows the **Spin-2** to be adjusted using an external controller with no electrical impact on the Faraday cage contents.

Mechanical noise

Mechanical artefacts are usually a stirplate bane and can be difficult to control. The fundamental issue is that the bilayer membrane represents an exquisitely sensitive transducer for mechanical movements and any vibrations presented to the chamber are received and amplified by the system. Relevant sources include those from the chamber holder, from within the chamber itself, and from the surrounding air.

Chamber holder

Vibrations associated with the chamber holder include the opening and closing of Faraday cage doors, and the motion of the stirrer and other items placed on the isolation table. Peristaltic pumps placed on the table within the cage are notorious noise sources, as are many fluid control systems placed in direct contact with the bilayer chamber. These problems are often addressed by placing the chamber on an isolated, stand-alone platform or stage which effectively separates the chamber from the offending noise source.

The mechanical components within the **Spin-2** have been precision engineered using high mass materials and the device operates smoothly as a result. Furthermore, the top of the stirplate is somewhat isolated from its base and so can function as a stage.

NOTE: The magnetic dipoles within the **Spin-2** are sufficiently strong so that the stirplate can be placed under a secondary stage if further isolation is desired.

Chamber

Vibrations within the chamber are usually a result of collisions between a stirbar and the chamber wall. These large amplitude artefacts are reasonably expected whenever a misalignment between the rotational axes of a stirbar and the stirplate exists. This misalignment can be easily corrected by repositioning the chamber so that the axes are in alignment. However, this approach is effective whenever only one side of the membrane is being stirred and can become intractable if stirring on both sides of the membrane are attempted.

The **Spin-2** addresses this difficulty by providing two rotating dipoles, one for each side of the bilayer membrane. This approach allows each stirbar to remain centered within its respective well without influencing the motion of the other. Careful positioning of the dipoles beneath the cup and chamber can eliminate noise artefacts due to stirbar collisions.

NOTE: Stirbar collisions are not an intrinsic property of the stirplate but are rather associated with the geometry of the cup/chamber. However, it is imperative that both dipoles be well centered for stirbar collisions to be eliminated.

Another source of chamber noise is associated with the movement of fluid during solution exchange and will not be considered here.

Surrounding air

Acoustic coupling from the surrounding environment can product a large, transient artefact into your data. Some researchers can find themselves turning the radio down or asking a coworker to not speak loudly next to the setup during a recording.

Acoustic noise can also come from a noisy device with the Faraday cage. Most notable are stirrers and pumps. While acoustic coupling from a radio is often transient, noise from a pump or stirrer can be continuous. However, this effect is usually of a much smaller amplitude when compared to the mechanical artefact these devices can produce.

Magnetic noise

Magnetic noise is not usually considered to be a problem since most researchers avoid stirring while recording. Nevertheless, magnetic effects remain the only artefact which cannot be eliminated by the careful design of a stirplate.

In general, a time varying field produced by a rotating magnetic dipole induces a small, but detectable, sinusoidal current in any current loops present. In the case of a bilayer setup, this loop would be the headstage electrodes.

NOTE: The resulting sinusoid can be differentiated from a 'ground leak' by the observation that its amplitude and period vary with the speed of the stirplate.

While magnetic artefacts cannot be eliminated, their effects can be reduced by (1) decreasing the strength of the magnetic field, (2) slowing the rate of change of the magnetic flux (spin rate), or (3) by altering the geometry of the wire loop within the magnetic field. The **Spin-2** uses highly focused magnets to reduce the strength of the magnetic field in the vicinity of the electrodes and the variable speed control allows the user slow the rate of change of the magnetic flux.

Noise abatement

The above discussion regarding various noise sources should make it apparent that a critical understanding of the principals involved can contribute immensely to the successful use of a stirplate while recording.

Since the **Spin-2** has been designed specifically for this purpose, care has been taken to abolish or minimize noise contributions from within the stirplate itself. As a result most noise artefacts a user will experience will be from either stirbar/chamber collisions or from magnetic effects. Here we discuss strategies useful in minimizing or abolishing these effects.

Collisions

Collisions between the stirbar and chamber will most likely be the largest amplitude noise artefact. Fortunately, this is also the easiest artefact to address. Take a moment to review the setup procedure described on page 8. The strategy described there is to first center the stirbar in the front chamber over the front dipole, then to adjust the position of the rear dipole and chamber so that the rear stirbar becomes well centered over the rear dipole.

We recognize that this procedure may seem cumbersome at first, but the approach allows tremendous flexibility in using the stirplate with cups and chambers of many sizes and geometries. Note that once the dipole separation has been set for a particular chamber, only small subsequent adjustments should be necessary to align the stirbars between uses.

Magnetic induction

Magnetic-induction effects are more difficult to control. As stated earlier, this effect stems from the raw physics and simple geometry of the setup and cannot be engineered away. However, steps can be taken to reduce the amplitude of the artefact.

The dipoles within the stirplate are digitally controlled to minimize the amplitude of the magnetic field present within the bilayer membrane. Moreover, the resulting magnetic field vector also resides entirely within the plane of the membrane. While this design reduces the amplitude of the induced current, further reduction can be achieved by (1) reducing the rotation speed of the stirplate, and (2) increasing the separation between the cup/chamber and the stirplate.

NOTE: We recommend that you adjust the speed of rotation before beginning the more complicated effort of relocating the chamber relative to the stirplate. However, if chamber relocation is necessary, then we suggest the use of a small stage under which the stirplate is placed.

Conclusions

We hope this discussion has given you a deeper understanding regarding several issues associated with the process of stirring while recording. We also hope that this discussion has provided you with the tools necessary to address these extra-stirplate issues.

APPENDIX

Specifications

Power	
Requirements:	12VDC (11 to 17 VDC) at 100 mA
Source:	Wall-mount DC power supply
DC connector:	2.1 mm power jack, *pos* to inside pin
Controls	
Controller:	Power On/Off switch, Speed rotary control
Stirplate:	Position adjust (rotary)
Display	
Controller:	LED; flashes once per complete rotation
Stirplate:	Magnetic field display; passive LCD
Speed range	300 to 600 RPM
Rotor	
Synchronization:	Counter-rotating
Position adjustment range: (center-to-center)	0.4 to 2.5 inches
Dimensions	
Controller:	5.4 x 0.5 x 2.0 in (W x D x H)
Stirplate:	5.5 x 8.0 x 2.3 in (W x D x H)
Weight	
Controller:	0.5 lb
Stirplate:	3.0 lb.

Warranty and service

Warranty

The **Spin-2** is covered by our Warranty to be free from defects in materials and workmanship for a period of one year from the date of shipment. If a failure occurs within this period, we will either repair or replace the faulty component(s). This warranty does not cover failure or damage caused by physical abuse or electrical stress (inputs exceeding specified limits).

In the event that repairs are necessary, shipping charges to the factory are the customer's responsibility. Return charges will be paid by Warner Instruments.

Service

We recommend that all questions regarding service be referred to our Technical Support Department.

Normal business hours are 8:30 AM to 5:00 PM (EST), Monday through Friday.

Our offices are located at 1125 Dixwell Avenue, Hamden, CT 06514.

We can be reached by phone at (800) 599-4203 or (203) 776-0664. Our fax number is (203) 776-1278.

We can be reached by e-mail at support@warneronline.com or through the web at http://www.warneronline.com.

Certifications

Declaration of Conformity

CE MARKING (EMC)

Application of Council Directive: 89/336/EEC

Standards To Which Conformity Is Declared:	EN55022 Class A EN61000-3-2 EN61000-3-3 EN50082-1:1992 EN61000-4-2 EN61000-4-3 ENV50204 EN610000-4-4 EN610000-4-8 EN610000-4-11
Manufacturer's Name:	Warner Instruments, LLC
Manufacturer's Address:	1125 Dixwell Avenue Hamden, CT 06514 Tel: (203) 776-0664
Equipment Description:	Stirplate
Equipment Class:	ITE-Class A
Model Numbers:	SPIN-2

I the undersigned, hereby declare that the equipment specified above, conforms to the above Directive(s) and Standard(s).

Place: Hamden, Connecticut USA

Signature:

Full Name: Burton J. Warner

Position: President

Declaration of Conformity

CE MARKING (LVD)

Application of Council Directive: 73/23/EEC

Standards To Which Conformity Is Declared:	EN61010-1:1993
Manufacturer's Name:	Warner Instruments, LLC
Manufacturer's Address:	1125 Dixwell Avenue Hamden, CT 06514 Tel: (203) 776-0664
Equipment Description:	Stirplate Safety requirements for electrical equipment for measurement and laboratory use
Equipment Class:	Class I
Model Numbers:	SPIN-2

I the undersigned, hereby declare that the equipment specified above, conforms to the above Directive(s) and Standard(s).

Place: Hamden, Connecticut USA

Signature:

Full Name: Burton J. Warner

Position: President

WEEE/RoHS Compliance Statement

EU Directives WEEE and RoHS

To Our Valued Customers:

Harvard Apparatus is committed to being a good corporate citizen. As part of that commitment, we strive to maintain an environmentally conscious manufacturing operation. The European Union (EU) has enacted two Directives, the first on product recycling (Waste Electrical and Electronic Equipment, WEEE) and the second limiting the use of certain substances (Restriction on the use of Hazardous Substances, RoHS). Over time, these Directives will be implemented in the national laws of each EU Member State.

Once the final national regulations have been put into place, recycling will be offered for those Harvard Apparatus products which are within the scope of the WEEE Directive. Products falling under the scope of the WEEE Directive available for sale after August 13, 2005 will be identified with a "wheelie bin" symbol.

Two Categories of products covered by the WEEE Directive are currently exempt from the RoHS Directive – Category 8, medical devices (with the exception of implanted or infected products) and Category 9, monitoring and control instruments. Most of Harvard Apparatus' products fall into either Category 8 or 9 and are currently exempt from the RoHS Directive. Harvard Apparatus will continue to monitor the application of the RoHS Directive to its products and will comply with any changes as they apply.

- **Do Not Dispose Product with Municipal Waste.**
- **Special Collection/Disposal Required.**