The Synchro® Blended Pulse Spray Control System Owner's Manual

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The Synchro® Blended Pulse Spray Control System

About this manual...

This manual is a cafeteria line of servings. Help yourself. Look it over and take what you need. You may not have to go through the whole line or you may want to come back for seconds of some things.

Here is our advice:

Everyone should read the **Cautions**; spraying is serious business. Be careful.

If your system is installed, has been checked out and ready to go, you can read **Quick Start** now and get underway. It is better if you read **Understanding Your Synchro Blended Pulse System and How It Works** and **How to Use Your Synchro Blended Pulse System** as soon as you can since you'll get the most benefit from your investment if you know how it works and what is possible.

Before you change your sprayer for another application such as higher or lower application rate, different speeds or whatever, you'll need to read **Selecting Nozzle Tips to Use With Your Synchro Blended Pulse System** so you'll get your nozzles chosen for the best job.

If your Synchro system is sitting, a pile of new and shiny parts and wires, next to your old sprayer, you'll need to read **How to Install Your Synchro Blended Pulse System** before and during your installation. It will help you to read **Understanding Your Synchro Blended Pulse System and How It Works** and **How to Use Your Synchro Blended Pulse System** before you start your installation job.We'll remind you to read **Selecting Nozzle Tips to Use With Your Synchro Blended Pulse System** after you have your system installed.

Things happen and you might have to someday read **Troubleshooting Your Synchro Blended Pulse System**. We think you'll be able to figure out when to read that chapter.

Some people really want to know exactly how Synchro works - the charts, graphs and big words. Reading **Technical Aspects of the Synchro Blended Pulse Spray Control Concept** is suggested for those folks.

We've found that some applications are unique and the Synchro hardware and capabilities can be put to work in special applications or with sprayers that have special or unusual configurations. Check with your dealer or Synchro engineers for help with those applications. They'll be happy to provide the latest **Special Technical Application Sheets.**

And what would a manual be without the **Parts List**?

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1. Cautions!

Agricultural chemicals must always be applied in accordance with the label instructions and state and local regulations. Always read and follow label instructions. Properly used, the Synchro system will allow you to follow application guidelines and regulations while providing much more flexibility and accuracy in your application. The Synchro system works with, but does not replace good sense or responsible, professional agricultural chemical application practices.

Read and follow the Synchro system installation and operating instructions in this manual. This is the first step in activating your warranty and earning a fast payback on your investment.

Retrofit to Spray Controllers:

The Synchro system is designed to operate with flow-based spray rate controllers. Pressure-based systems are not currently compatible with the Synchro system. Contact Capstan for further information.

Electrical:

Valve and actuator power for the system should be provided directly from the vehicle battery or power bus. Use recommended fuse sizes to protect both the Synchro system and your vehicle electrical system. Control power may be supplied from switched sources.

The master and slave control modules are designed for use with up to 16 standard valves per boom section. There are three boom sections on the modules. You can use up to 48 valves with each module. Always wire an approximately equal number of even and odd phase valves. If you are using special or high flow Capstan valves, contact us for more information on how many valves can be installed on each section.

Plumbing and Liquid Supply:

Synchro valves should be protected by 50 mesh strainers upstream of the valves. Flush your system prior to installing the Synchro system, install new strainers and service them often.

Do not exceed the maximum pressure indicated on the valves in your installation kit. Standard Capstan valves can be used at pressures up to 100 psi. Special or high flow valves will have different limits.

Capstan recommends a change of nozzle tips when installing the Synchro system. Increase the fan angle to improve overlap and increase the nozzle flow size to allow a wide range of flow control. For example, you might replace 8004 tips with 11008 tips.

The Synchro system is not recommended for banding or other sprays where there is no overlap from other nozzles. Contact Capstan for how to use with banding, hose drop and other applications.

Capstan retrofit valves are designed to be used with TeeJet® ChemSaver® nozzle bodies. The valves may not fit properly into worn or damaged nozzle bodies. Occasionally, a new TeeJet® valve body must be trimmed to allow a Synchro valve to be installed. Your Synchro care kit has a reamer for doing that.

Synchro valves should be as properly cared for as the rest of the sprayer. Rinse the system after each use and drain before winterizing. Be especially mindful of wettable powders and corrosive materials.

Replacement and Repair:

Use only Capstan-approved Synchro components, replacement parts, and accessories. Contact Capstan for service and repair.

Treat the Synchro components as you would any other important part of your sprayer. Clean the parts before service and wear protective clothing when you are adjusting, calibrating, cleaning or testing your sprayer.

2. Quick Start

Make sure you understand how to use your spray rate controller. You do not communicate with the Synchro system directly. Your rate controller is still your primary spray control tool.

If you have the Synchro pressure control system, pressure is controlled by the Synchro system and the Synchro panel in your cab. This is independent of flow, or spray application, rate. Remember your rate controller and your Synchro pressure controller are independent.

We suggest the following procedure for testing your system and getting a feel for how it works.

❶ Estimate your speed and application rate and desired spray pressure.

❷ Check to see that your nozzle tips are oversized for your average rate at the above conditions.

❸ Fill the tank with water, drive at your average speed.

❹ Set your spray pressure at what you normally use.

❺ See if your rate controller can maintain your desired rate. If not, you'll need to change nozzle tips or adjust pressure to correct.

❻ Use your controller to boost the application rate upward and down ward to cover your desired control range. If you can't get the range you'd like, then change nozzle tips or pressure settings.

❼ Once the range is set, go back to your average desired spray rate, drive along and vary your pressure to see the range of droplet sizes that are possible. ↖ P1/P2

Once your pressures and rates are set, drive along and vary your ground speed. See that the Synchro system maintains your pressure and droplet size while making flow corrections for the speed changes. Note how quickly your Synchro system can respond. Once you have a feel for what the revolutionary Synchro system can do and confidence that it can control your application, then you are ready for chemical application.

3. Understanding Your Synchro® Blended Pulse System and How It Works

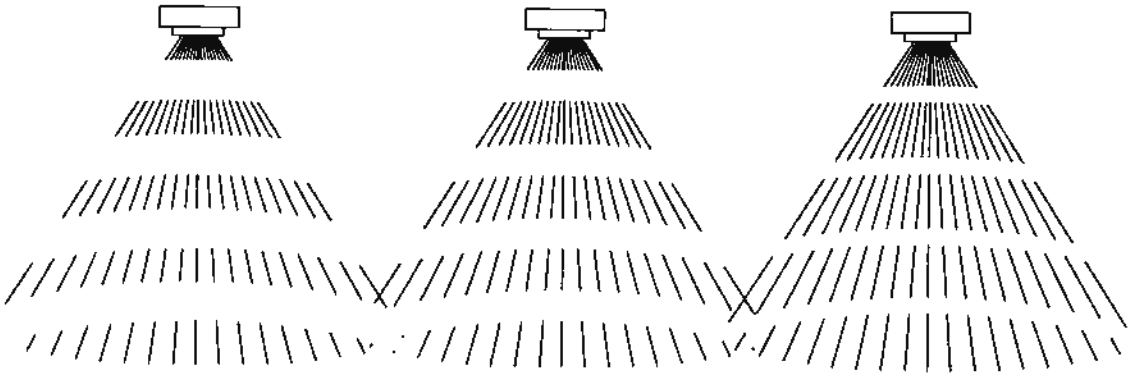
Using the Synchro system is a new way to spray. And it will make your job easier. The Synchro system leaves you the good things about ag spray nozzles but removes the old limits to nozzle performance. The Synchro Blended Pulse Spray Control system does not physically change your nozzles. Instead it changes the liquid flow into your nozzles. You can teach an old dog new tricks.

In the simplest terms, the system releases pressure's grip on flow rate and allows flow rate and pressure to be controlled completely independently of each other. And since pressure controls droplet size and flow rate controls application rate, you now have independent control of application rate and droplet size.

The system's new connection between flow and pressure opens up radical new possibilities for you, the spray operator, such as an up to an 8-to-1 control range for flowrate and droplet size adjustment without any change in flowrate - all easily controlled from the cab and on the go.

Capstan aimed to design the most simple system that would fit compatibly onto your conventional sprayer. In particular, we wanted a retrofit system which could be easy to install on old rigs as well as new ones and which would require only minimum component changes, if any. Our goal has been to enable operators to operate with basically the same tools as before, only with Synchro installed, the tools would give you much greater operating possibilities. We have put a big long pipe on the end of your wrench handle to give you the leverage to get your job done.

The Synchro system's primary mechanism is a solenoid valve which is set to cycle 10/15 times per second. The length of time the valve remains open during each cycle determines the amount of fluid released - the flowrate. The time while the valve is open is a spray pulse - liquid is pulsing from the nozzle tip. The time while the valve is closed is a spray pause - no pulse from the tip.



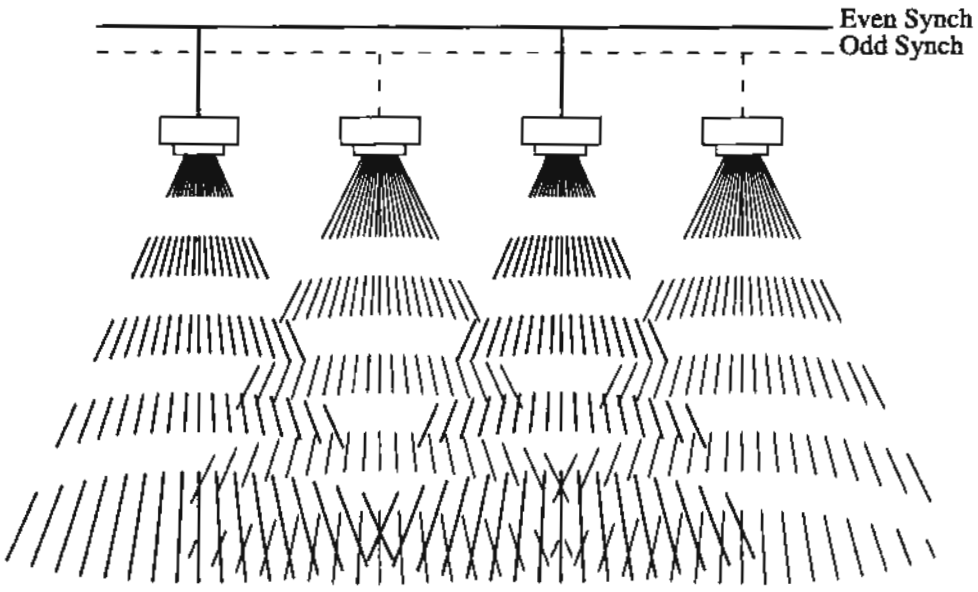
Low flow rate
Short pulses
Long pauses

Medium flow rate
Moderate pulses
Moderate pauses

High flow rate
Long pulses
Short pauses

The time between the start of each cycle is always 1/10 of a second but the length, or duration, of each pulse and each pause can be adjusted. When you want a low flowrate, the spray pulse itself is short and the pause between pulses is long. When you want moderate flowrates, the pulses and pauses are about equal in length and when you want a high flow rate, the pulses are long and the pauses are short. Capstan's electronic controllers automatically adjust the spray pulse and pause times to get the flow rate needed for application.

A nice, even spray pattern is important for the professional application of ag chemicals. Now should be about the time you start to wonder whether the pauses in the spray flow result in skipping or striping in the field. "If there is no spray coming out of the nozzles, then how can there not be unsprayed gaps in the field?"



We prevent those gaps through three means. It is like wearing a belt, suspenders and elastic waist pants. The first means is the natural tendency for spray droplets to overlap, mix and twirl as they move from the nozzles down to the target. This mixing, partly from the range of droplet sizes and speeds coming from the nozzles, and partly from the air flow created as the boom and sprayer travel, serves to create a hash of droplets moving down to the ground. The second means is the Capstan design of "blending" the spray pattern across the boom. The timing of the spray valves is alternated so that the start of each spray pulse is delayed 1/20 of a second after the start of the pulse from its neighbor nozzle.

This intermingles the spray pauses and pulses across the boom and allows them to blend. The third means is to use wider pattern nozzles, for example, using 110° fans instead of 80° fans. This further improves the overlap between neighboring nozzles, and, when combined with the alternating pulse timing, provides coverage between spray pulses.

By the way, you now know why the Synchro system is called the blended pulse system. Controlled pulses of spray are blended to give you greater uniformity in application. The spray flowrate is set by the length of spray pulses and pauses from the nozzles.

Capstan's Synchro design alternates the timing between neighboring nozzles to provide spray overlap during spray pauses.

Designing a slick, new and somewhat expensive nozzle body to match the technology made good business sense, but doing so would have required you to replace perfectly good TeeJet® bodies you had already installed. Realizing that Synchro valves when turned off performed the same function as nozzle check valves - preventing drips - we devised a way of fitting our solenoids onto conventional check valve ports. Testing the droplet sizes produced by the Synchro system proved that this design caused no significant deterioration in spray characteristics with check valve installations. One major simplification accomplished for the Synchro system!

The second simplification for the Synchro system was to devise a simple but robust means of tapping into your existing rate control system rather than developing a new system that would require you to throw away your perfectly good unit and learn a whole new system. We recognized that a number of different companies manufacture spray rate controllers and that their electronics designs are unique. Likewise, even a single manufacturer's various models worked differently.

We chose to make our job harder so that your job would be easier. We designed the Synchro system to work with the popular spray rate controllers already in the field - units with which you are already familiar and comfortable. That way an operator's transition from conventional spraying technology to the Synchro system is greatly simplified.

At the head end of a spraying system, usually a rate controller, like a Raven®, a Micro-Trak®, a TeeJet® or a Mid-Tech®, is installed to perform the usual automated functions for you. After setup, rate controllers receive your vehicle's speed signals and translate them into the necessary pressure changes to maintain a consistent application rate. An inline flow meter signals the actual fluid flow to the controller which combines this input with speed input and, in turn, opens or closes its flow regulating valve in order to decrease or increase pressure of the liquid supplied to the nozzles.

The Synchro Blended Pulse Flow Control System is designed to capture the signal sent to the regulating valve from the rate controller and use it to determine the intervals of spray pulses and pauses. When the rate controller, responding to the combination of speed and flowmeter signals, produces an output signal that says, "increase flow", the Synchro controller increases the time the valves remain open - the pulse time. When the "increase flow" signal stops, Synchro controller holds the time at the last setting. The controller's "decrease flow" signals are handled comparably. Since the Synchro system does not require the long time for a pressure regulating valve to open or close, flow changes are fast - the response time for conventional systems is reduced from seconds to fractions of a second with the Synchro system.

To tie your Synchro system into your rate controller, you merely unplug the cable going to the pressure regulating valve and plug the cable into the Synchro Flow Control Module. This sends the "increase flow" or "decrease flow" electronic commands into the Synchro system instead of to your electric valve.

The regulating valve, now relieved of its flow control duties, can be left right in place and put to better use as an independent pressure controller. The regulator valve is then plugged into the Synchro Pressure Control Module, which then gives you direct control over the nozzle pressure. Since spray pressure is the primary factor in spray droplet size and droplet size is a primary factor in spray drift, the operator now has control over the potential for spray drift.

Congratulations, you now understand the Synchro Blended Pulse Spray Control System, the most powerful system ever developed for ag spraying. Once you use it, you'll understand why the American Society of Agricultural Engineers awarded Capstan Ag Systems, Inc. an AE 50 Award, recognizing the Synchro system as an outstanding and innovative ag product.

4. How to Use Your Synchro® Blended Pulse System

If your Synchro system came originally with your sprayer or has been already installed, then you are just about set to go!

The Synchro system allows you to control **application rate** and **spray pressure**. Independently of each other.

Application Rate is controlled through your existing rate controller. Operate it as normal. When setting up your system, remember that the Synchro system gives you a much wider range of control. So you may be able to allow a wider range of application rates. Since many controllers allow you to enter a minimum or maximum allowable rate, you can probably increase the maximum and decrease the minimum rates. You will also be able to manually "bump" the application rate over a much larger range. Remember that your rates are no longer confined by the pressure range of your nozzles or pump. For more information, see the manual sections, "Selecting Nozzle Tips to Use With Your Synchro Blended Pulse System" and "Technical Aspects of the Synchro Blended Pulse Spray Control Concept".

Since the Synchro can respond much faster than most pressure regulating valves, you may need to adjust the speed at which your controller makes changes, brakes the valve or adjusts the valve. Remember, instead of adjusting an electric pressure valve to control flowrate, your Synchro system adjusts the pulse/pause ratio of the nozzle valves. Since the valves pulse 10 times per second, the flow rate can be changed very fast!

Remember, the flow rate, and therefore the application rate, is still controlled by your rate controller.

Spray Pressure can be controlled a number of ways, depending on the options installed on your sprayer and on your plumbing system.

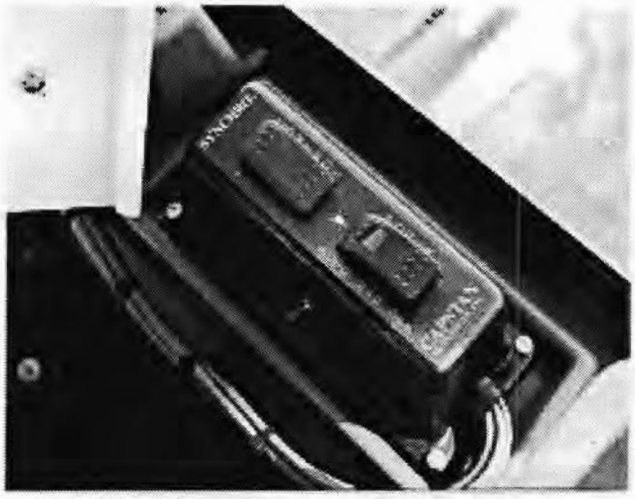
There are two reasons why you want to control pressure. First, as you change your flow rate, especially, over the wide range that your Synchro system allows, the pressure drop between your pump and your nozzles will change. And, with a centrifugal pump, you are moving your operation along the pump operating curve. So, if you want to maintain a constant pressure as you use the Synchro flow control to apply a wide range of application rates, then the pressure will need to be adjusted to compensate for your flow changes.

Secondly, remember that you can control spray droplet size, and therefore, the potential for drift, by adjusting the spray pressure. For more information, see the manual sections, "Selecting Nozzle Tips to Use With Your Synchro Blended Pulse System" and "Technical Aspects of the Synchro Blended Pulse Spray Control Concept". So, you can adjust the pressure to get the desired droplet size or pattern you want and then let the Synchro system and your rate controller take care of application rate.

The recommended way to control pressure is to use the **Synchro Pressure Control System**. This Synchro system is an active, closed-loop controller that automatically restores your spray pressure to any level you have set, regardless of your flow rate. As long as you are within the bounds of your nozzles and pump, Synchro pressure control will hold your desired pressure regardless of changes in application rate, changes in ground speed and boom turn ons and shut offs. The Synchro Pressure Control System consists of four components:

❶ The Synchro Cab Control Panel,
❷ The Synchro Pressure Control Module,
❸ An electric pressure regulating valve, and
❹ An electronic pressure transducer

which are all installed on your sprayer. The Synchro Cab Control Panel is the only thing you can easily see and it is your pressure control command center.



Note that the photo on the current product sheet does not show the setpoint selector switch.

There are three switches: the main switch, the pressure or valve adjust switch and the setpoint selector switch.

The **main rocker switch**, which is black and lighted, has three positions - Off, Manual and Auto.

OFF - turns off the pressure control system.

MAN - "manual mode" allows you to directly open or close the electric pressure control valve using the + or - detents of the adjust switch. Manual mode overrides the active control portion of the system. In manual mode, the Synchro Pressure Control Module and the pressure transducer are disabled.

AUTO - "automatic mode" allows you to set a desired pressure, using the + or - detents of the adjust switch. When in automatic mode, the Synchro Pressure Control Module adjusts the electric pressure regulating valve to maintain your desired pressure. So, as your application rate controller adjusts the flow rate, the Synchro system holds the pressure constant at your setting.

The **pressure adjust switch**, which is red, has two momentary positions, + and -, and a center neutral. Note that the switch must be held in either momentary position and returns to the center neutral when released.

When the main switch is in the AUTO position, the pressure adjust switch sets your desired pressure. Holding in the + position increases pressure and holding in the - position decreases pressure. When you release the switch, that pressure is maintained automatically.

When the main switch is in the MAN position, the pressure adjust switch is directly coupled to the electric pressure regulating valve. Holding in the + position increases pressure and holding in the - position decreases pressure. When you release the switch, that valve position is held. Note that only the valve position is held, the pressure may change as the flow rate changes.

The **setpoint selector switch**, which is a small toggle switch on the side of the panel, has two stationary positions. Think of them as the old push button selectors on your radio. Remember how you could set in your "favorite" station? The setpoint selector switch allows you to store your two "favorite" spray pressures. Changing the position of the switch allows you to toggle back and forth between your favorite pressures. You might use this to set in a low pressure - to get large droplets - when you are near the edges of a field and worried about drift, and a high pressure - when the danger of drift is low and you want maximum coverage from smaller droplets.

To use the setpoint selector switch, place the main switch in the AUTO position and use the pressure adjust switch to set in your first favorite pressure setpoint. Then flip the setpoint selector switch to the other position and again use the pressure adjust switch to set your second favorite pressure. Depending on how your system is plumbed, you may have to have the nozzles spraying in order to set these pressures. As long as your main switch is the AUTO position, you can now use the setpoint selector switch to toggle between the preset pressures.

If you don't have the Synchro Pressure Control System, you'll need to manually control your spray pressure. If you have a simple, spring-actuated pressure relief valve in your system (probably with a positive displacement solution pump), you can adjust the spring tension in the valve to set your system pressure. Over a limited range, the pressure relief valve will respond to flow changes and maintain a constant pressure.

If you have a butterfly- or ball-type pressure regulating valve, either as an in-line or bypass control valve, you can manually adjust the position of the valve to set your system pressure. Note that the pressure may change with flow, or application, rate. With proper plumbing, you can reduce the variations but remember that this is not an active control technique.

If your pressure regulating valves are electric, then you can wire a momentary toggle switch to the cab so that you can manually adjust the pressure regulating valve. Or you can buy ready-made kits with electric valves and switch panels. For example, the TeeJet® Model 734 or 744 Sprayer Control Panel would work fine. See the manual section, "Special Technical Application Notes," for more information on this configuration.

In the field, operation of Synchro is simple. Use your rate controller for application rate control. Adjust your pressure to get your desired droplet size and pattern.

We suggest that you experiment with water in your tank to get a feel for how the Synchro system operates and responds.

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5. Selecting Nozzle Tips to Use With Your Synchro® Blended Pulse System

Selecting nozzle tips for your normal sprayer can be easy or hard - depending on your application. Most of the time, your job is mostly to take your application rate (gallons per acre or "gpa"), your speed (miles per hour or "mph") and your nozzle spacing and then calculate the flow rate (gallons per minute or "gpm") you need from each nozzle. Most spray nozzle catalogs have an instruction page that explains nozzle selection. You should read that. Now would be a good time.

Selecting a nozzle to use with Synchro is just a little different.

Shortcut! If you are already a "pro" on spray nozzles, then the important thing for you to remember is that the Synchro system can only reduce the flow from a nozzle. So you'll always oversize your nozzles when you switch to Synchro blended pulse spraying. A good rule of thumb is to double your nozzle size (flow rate) when you run your Synchro system. Or, if you need to keep your droplet size fixed, increase your nozzle size (flow rate) by about 2/3 and increase your pressure by about 50%. Also, you can improve uniformity of your application if you use nozzles with a wider spray angle.

A little background on spray nozzles...

First, let's consider a few facts about spray nozzles. The important things to remember about nozzles are:

1. **Flow rate**
2. **Pressure**
3. **Droplet size**
4. **Spray pattern**

Let's look at **flow rate** first:

The only arithmetic you'll need is this:

$$\text{gpm} = \frac{\text{gpa} \times \text{mph} \times \text{nozzle spacing in inches}}{5{,}940}$$

Use this equation to figure out how much liquid has to come out of each nozzle every minute in order to get your application rate. For example, if you want to spray 25 gpa and your ground speed is 6 mph with your nozzles spaced every 20 inches, then your gpm should be

$$\text{gpm} = \frac{25 \text{ gpa} \times 6 \text{ mph} \times 20 \text{ inches}}{5{,}940} = 0.51 \text{ gpm}$$

Now this is exactly how the tables that are in your nozzle catalogs are calculated. The nozzle folks have done the calculations for you. We do suggest that you read your nozzle catalog for the most complete information on nozzles. In those catalogs, you'll usually use the speed, application rate and nozzle spacing to select your nozzle from a simple table.

But what about **pressure**? Spray nozzles are just holes in the end of pipes. So the harder you "push" the liquid, the more flow you'll get through the nozzle. Most nozzles are designed to operate best over a range of pressure. For example, most flat fan nozzles used on typical booms work best at around 40 psi pressure but will do ok in the range of 15 to 60 psi. If you go outside the optimal range for your nozzle, your droplet size and spray pattern will change - seldom for the good. We'll discuss those in the next sections.

The trouble with spray pressure is that it takes a lot more pressure to get a little more flow. The flow rate from your nozzle is actually proportional to the square root of your pressure. But here is an example that may be more clear. Every time you want to double your flow rate from a nozzle, you have to quadruple your pressure. Let's say you had picked a nozzle for the above example that gave you your 0.5 gpm at a pressure of 40 psi - for example, a TeeJet® 8005 flat fan nozzle. If you wanted to boost your spray rate to 50 gpa, then you'd need 1.0 gpm from your nozzle. You'd have to to increase your spray pressure to 160 psi! Then if you wanted to reduce your application rate to 12.5 gpa, then you'd have to decrease your pressure down to 10 psi! From a practical view, high pressures, even if your nozzles work well with them, require costly pumps, more horsepower, expensive plumbing parts and put more wear on your equipment. Low pressures are hard to control.

Your rate controller can only give you a very limited range of spray application rates while staying in the recommended range of nozzle pressure. Let's say your nozzle, in the above example, has a recommended pressure range of 20 to 60 psi. So if you are operating at 25 gpa and 40 psi, then going up to the pressure of 60 psi would give you an application rate a little over 30 gpa. If you went all the way down to 20 psi, your application rate would be a little under 18 gpa.

18 to 30 gpa is not a wide range if you have a lot of speed variation or if your want to do a variable rate application. So, trying to use pressure to make big flow rate adjustments is a losing deal.

But the really big problems with changing pressure are the effects on **droplet size** and **spray pattern.** For a given nozzle, spray pressure determines the size and range of droplets in the spray.

Droplet size is very important for maximum performance of your chemical application. If your droplets are too large, you will not get good coverage and you will not get economical control of your weeds, insects or crop disease. You'll lose money by having to respray or having to apply high rates. If your droplets are too small, they may drift and damage nearby areas and you may get fined. Many pesticide labels and local regulations specify the droplet size you should use for application. Droplet size is an important topic and there is plenty of information available. We suggest you contact your local agricultural extension agent, chemical salesperson, nozzle manufacturer or your Synchro dealer for more information. We have left room in the back of this manual for you to add your nozzle catalog or data sheets. You will need that information to take the maximum advantage of what your Synchro system can do for you.

In general, increasing pressure decreases droplet size. Significantly. For example, a TeeJet® 11003 nozzle operating at 40 psi and applying 9 gpa will produce a "medium" size class spray. But if you increase the pressure to just 50 psi to apply 10 gpa, the size classification becomes "fine" - a likely chance for spray drift. By the way, droplet sizes are often classified into categories of "very fine", "fine", "medium", "coarse" and "very coarse", Extremely coarse.

Pressure also affects your spray pattern. If you have TeeJet® 8002 nozzles operating at 40 psi, spaced at 30" on your boom and your boom 18" above the crop, each nozzles will cover a 30" swatch. If you (or your rate controller) decrease your pressure to 15 psi, then your nozzle swath coverage is only 23". So only 77% of your crop is going to be sprayed.

How to select your spray tips for use with the Synchro system

Normally, when you select a nozzle tip, you are selecting it for a single operating condition. For example, if you want to spray a "coarse" droplet size at 30 psi, 20" nozzle spacing, 8 mph and achieve a spray rate of 16 gpa, you might pick a TeeJet 8005® fan nozzle to do the job. A little thumbing through the catalog to check the application rate tables and droplet size tables and you're in business.

It is not much different with your Synchro system except you will be choosing a nozzle for a **range of operating conditions, not just a single condition.** It can be a range of droplet sizes, application rates, pressures, ground speeds or a combination of those.

The general principle of nozzle selection with your Synchro system is to select the nozzle which gives you the highest flow rate you need at the lowest operating pressure you need for your application. Then, when you need less flow rate, say, for slower speeds or lower application rates, or for when you increase the pressure to get smaller droplets, your Synchro system will chop the flow rate downward to achieve your application. That's all there is to it!

Most Synchro users select their nozzles to accomplish one of the following goals:

1. Variable application rate or speeds

Let's say you want to maintain your droplet size and pattern and use one nozzle for a wide range of application rates and/or ground speeds. This is a perfect job for your Synchro system.

Just take your maximum application rate and ground speed. Select your spray nozzle and pressure to provide that rate and give you the droplet size and pattern you want. Then your Synchro system can automatically handle lower rates and ground speeds. The principle here is to select your nozzle tip based on the highest flow rate you need and then use your Synchro system to reduce the flow rate for the other conditions.

***Example** - You want to run your spray pump at 40 psi, spray with "coarse" size class droplets, drive in a 4 - 8 mph range and do variable rate applications at 10 - 30 gpa. Then your highest flow condition is when you are applying your maximum rate, 30 gpa, at your fastest speed, 8 mph. So, looking in the TeeJet catalog, you see that a 8008 flat fan nozzle spaced at 20" will give you exactly*

110°?

what you want. So install that nozzle on your sprayer. Then when you slow down and/or switch to your lower rates, your Synchro system will automatically reduce that flow rate right down to give you the speed and application rate you want. All while keeping your spray pattern and droplet size unchanged.

2. Variable droplet size.

Another common use for Synchro systems is to help reduce spray drift by giving you control over droplet size. Let's say you want to be able to normally spray using a "medium" droplet size but quickly switch over to a "coarse" or "very coarse" spray when you are near sensitive areas or when the wind may be getting stronger.

Just select a nozzle that will give you your largest droplet size and the application rate you need at the lowest possible pressure to maintain a good pattern. Then, increase your pressure to decrease your droplet size and let your Synchro system compensate your flow rate for the higher pressure.

The principle here is to select your nozzle for the largest droplet size and lowest pressure. Then, at higher pressures, your Synchro system will reduce your flow rate to maintain your application rate.

***Example** - You want to spray 10 gpa at 6 mph with nozzles no closer than 20" and be able to use "medium", "coarse" or "very coarse" droplets. So looking in the TeeJet® catalog, we see that the TT11003 Turbo TeeJet® nozzle can cover that droplet size range if you vary the pressure from 20 to 60 psi. At 20 psi, the application rate is 10.4 gpa so that is covered.When you increase your pressure to 60 psi, your Synchro system will automatically adjust the flow rate back to the proper level to maintain your 10 gpa rate.*

In this example we used the droplet size categories, adopted by the British Crop Protection Council (BCPC), to explain how to choose your nozzle. If you want to use any other specifications such as droplet volume median diameter (vmd), or volume percentage of fine droplets below a certain size, you just use the same procedure as we explained. Just be sure to have the droplet size information you need about the nozzle you are considering. If you are selecting your nozzle based on production of small droplets or "fines", then use the lowest generation of fines to choose your minimum operating pressure. Remember that the principle here is to select your nozzle for the lowest generation of fines and lowest pressure. Then, at higher pressures, your Synchro system will reduce your flow rate to maintain your application rate.

3. Variable rate and variable droplet size control

This is the widest range of control. Let's say you want to use your rate controller to adjust for speed changes over a range and have independent control of your droplet size. No problem with your Synchro system.

The principle here is to combine the principles of the variable rate and variable droplet size nozzle selection techniques. Just as we did in Example 1, pick your nozzle tip based on the highest flow rate you need and then use your Synchro system to reduce the flow rate for the other conditions. But now, just be sure to do this at the lowest pressure -that is, the largest droplet size you need.

Example *- You want to be able to control your droplet size in order to get "medium" or "coarse" droplets for 10 gpa at 4 to 12 mph in a rough, hilly field. Your boom is set up for a 20" nozzle spacing. Ok, so the worst case for highest flow is the 12 mph speed. 10 gpa at 12 mph is going to require 0.40 gpm. So you need a nozzle that will give you "coarse" droplets and a flow rate of 0.40 gpm. Looking in the TeeJet® catalog, you see that a 8005 flat fan nozzle will do that. The last thing you do is make sure that your nozzle will achieve the "other corner" of the control envelope - that would be a "medium" droplet at 3 mph ground speed. The flow rate you need there is 0.13 gpm. Looking in the catalog again, we see that the 8005 nozzle will produce a "medium" droplet size at a pressure of 50 psi and a flow rate of 0.56 gpm. Your Synchro will easily chop the 0.56 gpm flow rate down to the 0.13 gpm you need. Another Synchro system success story!*

4. Big droplets and low application rates.

Often, for drift management and efficient use of time, water and nurse trucks, applicators want to make applications at low rates but use large droplets. This is usually troublesome since most nozzles that produce large droplets have large openings and therefore have high flow rates that lead to high application rates.

The principle here is to select your big nozzle to give you the droplet size you want and then use your Synchro system to reduce the flow rate down to get the application rate you want.

Example *- You want to spray 5 gpa using "very coarse" droplets at a ground speed of 8 mph, a spray pressure no lower than 30 psi, and nozzles on a 20" spacing. You look in the TeeJet® catalog and find that an XR8008 at 30 psi produces "very coarse" droplets. But this nozzle applies 26 gpa at these conditions. No problem with your Synchro system! Just install the nozzles and set up your rate controller for 5 gpa. The Synchro system will chop the application rate down to 5 gpa from 26 gpa.*

One final word - every now and then, you may find that your spray control demand exceeds even the amazing capabilities of the Synchro system. You may still have to adjust your speed, rate or pressure conditions to get the control range you want. Synchro is a powerful tool but even it does have limitations.

Remember, these are just examples to show you how to select your nozzles in order for Synchro to make your spraying more efficient, safe and profitable. You can use these general principles with any application job, type of nozzles or nozzle manufacturer. And don't forget, your Synchro dealer is your "partner in precision"; just ask for more information and help.

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6. How to Install Your Synchro® Blended Pulse System

Put down those tools! Unplug that drill! Don't start installing your new Synchro system until you know what you're doing. Trust us, a little thinking ahead will save you plenty of time and aggravation. And, you'll be sure that you have all the right parts in your hand when installation time comes.

Installing your Synchro system is simple and follows good common sense. While the details may vary with how your particular sprayer is set up, we'll explain the general approach here. It can be a one person job but it goes much faster and easier with two people. You'll need your tool box. Nothing special, just your usual pliers, screwdriver, wire cutters and drill.

The installation steps are:

1. Laying out and planning the system.
2. Preparing the sprayer for installation.
3. Mounting the flow and pressure modules.
4. Installing the nozzle valves and the system cabling.
5. Making the connections to your rate controller and dry testing the system.
6. Tuning the system and your rate controller and wet testing the system.

Now the details...

LAYING OUT AND PLANNING THE SYSTEM.

Installation will go much easier if you understand what you are doing instead of just following instructions. So, now would be a good time to reread the section, "Understanding Your Synchro Blended Pulse System and How It Works". That will help you understand the parts of the Synchro system and how they connect to each other and to your sprayer. The Synchro system consists of four major components, the flow module and the nozzle valves, the pressure module (with pressure sensor) and the cab control box. Wiring connects the modules to the valves and to your rate controller. The cab panel is used with the pressure module. If you don't have a Synchro pressure control system, you will not have a cab control box.

Remember, the Synchro system works with your existing rate controller. So, if you are installing one of those at the same time as your Synchro units, then your first step is to lay out the rate controller and make sure you understand how it is plumbed and how the control panel operates. Since your Synchro system uses the rate controller as a backbone for your Blended Pulse Spray Control System, you could go ahead and install the rate controller. If you are new to rate controllers, then you should probably install that system first and make sure it works properly. Follow the manufacturer's instructions carefully. The Synchro system can only be as

accurate as your rate controller. Be especially careful to properly install and calibrate the flow meter. Spray a few tanks of water to get a feel for the set-up and operation of your controller. But don't get too accustomed to it since you're about the turbocharge it with your Synchro unit. If you have used rate controllers in the past and understand them pretty well, then you can probably wait and install the controller and the Synchro system at the same time.

Your Synchro system requires electrical power to operate. You will need at least 5/8 amp (625 mA) for every nozzle valve on your system. Make sure that you have enough current supply from your alternator. Remember, you'll need this power in addition to all the other electrical accessories you'll be using with your Synchro system. Don't forget that your rate controller, boom-shut off valves, GPS system, foam marker and lights may be a considerable load on your electrical system. You may need to upgrade your alternator, especially if you have a large spray boom.

Now let's look at the general layout of your installation. You can arrange your Synchro parts out on the floor if that helps you see where you are headed once you start installing on your sprayer. The typical layout of a rate controller, before the addition of the Synchro system, is shown in Figures 1a and 1b. Figure 1a is simplified to show a centrifugal pump with the pressure regulating or "servo" valve in the "in-line" configuration. By the way, the "in-line" configuration means that your pressure regulating valve is "in" the spray "line" going out to your boom. If your valve is installed so that it is in the "bypass" line between your pump and your tank, that is called the "bypass" configuration as shown in Figure 1b.. You might have a diaphragm, piston or roller pump with a pressure relief valve. We'll talk more about that later. For now, let's stick with the "in-line" or "by-pass" set-up with a centrifugal pump. In general, if you are using hydraulic "by-pass" agitation for your tank or your pump capacity is far greater than your flow demands for spraying, your Synchro system will perform better if you place your pressure regulating "servo" valve in the "by-pass" position.

For simplicity, the remaining figures will show an "in-line" configuration since the general layout for the two configurations is identical except for the valve location.

The inputs to the controller are: 1) 12 Vdc power from your vehicle electrical system, 2) the ground speed from your radar or magnetic pickup and 3) the liquid flowrate from your liquid flowmeter installed in your supply line to your booms. Those inputs are critical to your rate controller. Installing your Synchro system does not affect those wires. Leave those alone.

The Synchro (Master) Flow Control Module

Figure 2 shows you the wiring you'll have to do to connect the Synchro Flow Control Module to your spray rate controller. We are going to talk you right through that, and all the other figures, in detail. As we've said, the speed, power and flowmeter lines are not changed. Figure 3 shows you the details of the connectors and pins on the module. We've made your job easy since the cables are designed in most cases to prevent you from connecting something wrong. You can also order extension cables for any cable.

Power: First, connect your battery voltage to the 4-pin connector on the upper left of your module. Use the Power cable assembly for that. This power is used to drive your nozzle valves. Next, connect a switched "ignition" voltage to the 2-pin connector on the lower left of your module using the *ignition cable assembly*. This switched power activates the module electronics when you supply power.

There is also a green ground wire and ring terminal which protrude from the potted side of the module. The wire is to reduce electrical noise and interference. It is not a power ground intended to carry current. The green wire should be connected to your chassis frame or the Synchro back mounting plate for the enclosure.

Nozzle valves: The Synchro nozzle valves are mounted on the nozzle body for each nozzle on your boom. We'll discuss that later. With your flow control module, you can have three individual boom sections. Each section can be turned off or on independently of the others. Across the top of your flow control module are three 3-pin connectors. These supply the pulsing commands to your valves. Remember from the section, "Understanding Your Synchro Blended Pulse System and How It Works" that the valve pulsing is blended by staggering the pulsing of adjacent valves. That staggering takes three wires - an "odd" pulse, an "even" pulse and a common line. Connect a 3-wire cable to each of these connectors and run each one out to the start of your spray boom section. Once you get the wires there, you'll connect them to your first Synchro nozzle valve and then plug the valves into each other along the boom. We'll discuss that in detail under step number 4.

Boom shut off valves: Many sprayers have electric boom shut off valves installed in the liquid line going to each boom section. Look back at Figure 1. They are not only handy for turning off boom sections but they are important in letting the spray rate controller know that you are shutting off boom sections. Remember, when you turn off a boom section, you are spraying less ground so the controller has to adjust the total flowrate in order to keep your application rate correct. The Synchro flow control module can shut off a boom section by turning off each of the Synchro nozzle valves on that section. So, if you have electric boom shut off valves, you'll need to run the shut off wires from your controller to the 4-pin Boom Shut Off connector on the lower right of the Synchro Flow Control Module. Use the *Boom shut off input adapter*. This is the cable which has a 4-pin connector that will fit the module and terminates in three spade connectors. Connect the boom shut off lines from your controller to these spade connectors. If you are also installing the Synchro Pressure Control System (described later) and using the "Run/Hold" option with your in-line pressure regulating valve, you will also need to install the Run/Hold adapter plug and cable which gives you access to the Run/Hold Output Pin D of the module. We will tell you more about that connection later.

You can optionally keep the original electric shut off valves in place and wired into your rate controller. If you do this, we recommend that you run a tee cable from your valves over to the spade connectors on the adapter cable which runs to the Synchro flow control module. This will make sure that the proper Synchro nozzle valves are also turned off anytime you shut off a boom using your electric shut off valves.

This reduces the electrical load on your system and extends the life of the Synchro nozzle valves and helps prevent drips from your nozzles.

The important thing to remember about the Boom Shutoff connector is that the pulse command to each boom section is turned on only when the corresponding pin of the connector is switched to a 12 Vdc voltage. Keep this in mind if you are testing your module before installing it. If you do not supply a 12 Vdc signal to the boom shut off pins, the nozzle valves for that section will not be activated. You can run a jumper wire from your battery voltage to the pins to test the boom sections. Be sure your module is grounded.

The Slave connector: If you have more than three boom sections or more than 16 valves per boom section or more than 48 valves total, then you will need a Synchro Slave Flow Control Module. That module connects to your Synchro Flow Control Module using the 2-pin connector in the lower center of the module. Using the slave module is explained in more detail later in this section. If you don't have a slave module, then you will not use this connector. But be sure to prevent the pins in it from being shorted. There is a cover plug installed in the module. Leave this plug in place unless you have a slave unit. If you have a slave module, remove the cover plug and place it in the "slave output" connector on your last slave module in the system. If you do have a Synchro Slave Flow Control Module, then we will call the module that you connect directly to the servo valve output of your rate controller, the "master" module.

The Servo Input: The most important connection to the Synchro Flow Control Module is the Servo Valve input. Remember, the Synchro system intercepts the commands your rate controller sends to the servo valve and converts those commands into spray pulse commands. Unplug the cable from the rate controller to the servo valve and plug it into the 3-pin Servo Input connector in the lower center of the module. You may need one of our valve input adapter cables depending on which type of rate controller you have. Your rate controller instructs the Synchro Flow Module to increase or decrease flow by changing the voltage on pins B and C of the connector. When pin B is high and pin C is low, the module increases flow rate. When pin B is low and pin C is high, the module decreases flow.

At this point, the input wires to your servo (pressure regulating) valve are left hanging. We'll take care of those in a following section, Pressure Control Options.

The Synchro Slave Flow Control Module

If you have more than three boom sections or more than 16 valves per boom section or more than 48 valves total, then you will need a Synchro Slave Flow Control Module. If you don't have a slave module, then you can skip this section. The slave module is the same size and shape as the master flow control module. The connections are similar.

You can "daisy-chain", that is, keep adding slave sections as you need. There is no practical limit to how many slave modules you can add. Just keep connecting the Slave Input of each successive slave module to the Slave Output of previous slave module.

Remember that all valves on your system will be receiving the same flow pulse commands (duty cycle) regardless of how many slaves modules or boom sections you have.

Figure 4 shows how to wire your slave modules and Figure 5 shows the details of the module connectors.

Power: Battery power and switched power are input to the 4-pin and 2-pin connectors, respectively on the left side of the module. You can tee your switched power off the cable going to your master module. However, we recommend that you run a dedicated battery power cable (the 4-wire, 4-pin cable) to the slave module. The fuse size in the battery cable may not support enough current for all your valves and you may have excessive voltage drop if you tee into the battery power cable going into the master flow module.

Nozzle valves: The boom section connectors (the 3-pin connectors across the top of the module) are connected to the nozzle valves on the additional boom sections just like the master module.

Boom shut off valves: The boom shut-off connector on the slave module is used just like the connector on the master module. Each Boom Section output is controlled by a pin in the Boom Shutoff connector. There are two general ways you might use your slave module. One is if you have more than 3 boom sections and the other is if you have more than 48 nozzle valves total and more than 16 nozzle valves on a single boom section.

If you have more than three boom sections and each section has 16 valves or less, then your slave module will control the additional one, two or three boom sections. Just wire the nozzle valves from the additional boom sections to the Boom Section connectors on our slave module and make sure the matching pin in the Boom Shutoff connector is wired to your boom section control switch or your rate controller.

If you have more than 16 nozzle valves on a single boom section, then you should divide the boom section into two or more sub-sections. Each sub-section can have up to 16 nozzle valves in it. Connect each sub-section to a Boom Section connector and make sure that you tee your Boom Shutoff signals such that all the boom subsections are activated when you turn on the entire boom section. Just make sure that you send your Boom Shut off signals to the correct pins in Boom Shutoff connectors in the Flow Control Module and the Slave Module. Don't worry too much if you get the boom shut off connectors mixed up. When you test the system later, you'll see right away if a wire is misplaced and you can simply reverse the shut off wires or the boom nozzle valve output wires for the boom sections that are incorrect.

The Slave Inputs and Outputs: The slave module receives commands from the master module, beefs them up, and then routes them to the additional or "slaved" nozzle valves or boom sections. The communication between the master and the slave is a two-wire cable. Connect one end of the cable to the Slave Output connector on the master flow module and the other end to the Slave Input on your slave module. As you add more slave units, follow this routine. Remember, when you get to the last slave in your chain, you should have a cable going into the Slave Input connector on it and no connection on the Slave Output on it.

Pressure Control Options

Remember that the Synchro system controls your flow rate by adjusting pulses of spray from the nozzles? Remember how this freed pressure so that you could use it for droplet size control? Now let's look at how you can set up your system to take advantage of that.

Look back at Figure 2. Notice that when we moved the servo valve cable output of your controller from the electric pressure regulating ("servo") valve to the Synchro Flow Control module, this left your servo valve control wires hanging. We'll now take care of those wires and give you independent control of your spray pressure valve.

Remember, you've *never* really had control of your pressure before - your rate controller used that for control your spray rate. Now you have the power to select the pressure you want to spray with.

The recommended method for pressure control is the Synchro Pressure Control System. The Synchro system gives you finger tip, active control of the spray pressure. By active, we mean that the pressure is automatically maintained at the point you set, *regardless of the sprayer speed and application rate*. So, as your sprayer speed changes or you boost or lower your application rate, the Synchro system maintains the constant pressure you set. And, the Synchro finger tip control panel allows you to preset two pressures and switch directly back and forth between them. You can set a low pressure (for bigger spray droplets and less drift potential) near the edge of your fields and a higher pressure (for better coverage and chemical effect) in the interiors of your field.

The Synchro Pressure Control System consists of three parts: 1) a Synchro Pressure Control Module that houses the electronics of the system; 2) an electronic pressure sensor; and, 3) a cab panel control box.

Figure 6 shows how the pressure control system is installed after the flow control system (Figure 2) is in place. Figure 7 shows the details of the pressure control module connectors.

Connections to the module are simple. The cab control box attaches to your battery voltage using the two conductor power cable. From the control box, the control cable runs to the module and attaches to the Power connector (lower left of module), the Control Input connector (lower center of module) and the Setpoint Control connector (upper left of module).

Remember that your flow control system and your pressure control system do work independently. However, there is one important electrical connection between the two systems that we suggest you make. Often when spraying, you will turn off all your spray booms using the boom shut off switches on your rate controller. For example, you'll turn off your booms when turning at the end of a row. This usually causes a change in your spray pressure and the pressure control system will adjust the electric valve and try to return the system to your pressure setting. Then, when you turn your booms back on, you may see a great pressure spike or drop.

This problem is greatly reduced when you have your electric pressure-regulating valve in the "by-pass" configuration. In that case, you can usually just set the jumpers to the "run" setting and the system will work fine.

If your system has the electric pressure regulating valve in the "in-line" configuration, you will probably want to install the run/hold wiring and set the jumper to the "run/hold" settings.

In that case, you use the Run/Hold line to "notify" your pressure control system that you have turned off your booms and just want it to "hold" the pressure valve position until you turn your booms back on. At that time, you want the controller to return to "running" and controlling your spray pressure.

The correct way to install the Run/Hold link between your system is shown in Figure 6a. Your installation kit will have two adapter plug/cables. One cable is installed between your boom shut off connector on the flow module and your rate controller shut off lines. From the adapter plug you'll see a wire and spade connector. That is the run/hold line coming from your rate control module. When it goes low to 0 dc, it signals that you want to "hold" the valve position.

The other adapter plug/cable goes between your Synchro cab panel harness and the Pressure Control Input connector on your pressure control module. It too has a wire and spade connector leaving the plug. By connecting the Run/Hold output of the flow control module to the Run/Hold input on the pressure control module, you will link the logic between the two systems.

Install the electronic pressure transducer at a convenient place in your spray plumbing and connect it to the module at the Sensor Input connector (upper right of module). In general, performance is better when you place the pressure sensor as close as possible to the main supply line to your boom and as close to the boom as possible. However, to keep cable lengths shorter and possibly keep the sensor in a place where it is less likely to be damaged, you may want to position the sensor closer to the module. Wherever you mount it, avoid placing it near elbows, tees and valves since the pressure readings near flow obstructions can be inaccurate.

Then, connect the electric pressure regulating ("servo") valve to your pressure module at the Control Valve Output connector. A number of adapters are available to convert the Capstan cable to the connectors used on most common valves.

Once installed, the Synchro Pressure Control System is used as explained in the Section, "How to Use Your Synchro Blended Pulse System".

Another option for pressure control is to wire your pressure regulating valve to a three-way, double-pole or triple-pole switch such as those used on TeeJet® Series 700 spray panels. If you take this route, remember that you will not have active pressure control. So, as your flowrate changes, either to speed changes with your vehicle or variable rate applications, your boom pressure will change. The severity of this change will depend on your pump, liquid and boom plumbing, application rates and nozzles. Capstan recommends the that you install a Synchro Pressure Control System.

Now, we've explained every connection you'll have to make for installing the Synchro Blended Pulse Spray Control System. By laying out your components and cables and finding the right components on your sprayer ahead of time, you'll find that the actual installation will go faster, cleaner and you'll be spraying in no time.

So now let's get down and dirty and get to work.

So here is your system planning and layout checklist:

- ❑ 1. Read this section of the manual; understand how the Synchro system works.
- ❑ 2. Verify that you have sufficient electrical power for all the valves and accessories. Upgrade your alternator if needed.
- ❑ 3. Install your rate controller and make sure it works properly.
- ❑ 4. Unpack and lay out the parts and components for your system.
- ❑ 5. Make sure you have all the correct cables and connectors.
- ❑ 6. Lay out your Synchro flow module and connections.
- ❑ 7. Layout your Synchro slave flow modules, if used.
- ❑ 8. Determine how you will control pressure; lay out the Synchro pressure module.

PREPARING THE SPRAYER FOR INSTALLATION

Before installing our new Synchro system, there are a few things you should do to your sprayer.

First, please be sure that your spray rate controller is working properly now - before you install your Synchro system. This system can work magic for spray applications but it cannot repair a broken rate controller.

Second, be sure to flush any chemical residue from the spray tanks, lines and nozzles. It is much easier to flush out any debris from your liquid lines now than it is to disassemble each one of your Synchro nozzle valves and clean them individually. Trust us, the time you spend cleaning your system now will save you plenty of time and aggravation later.

We recommend that you then drain your spray system so that liquid does not drip while you are working on the spray plumbing and nozzles. Also, this is a good time to hose down and pressure wash your sprayer. You'll be working on the booms and crawling around the vehicle. The cleaner and safer the vehicle, the cleaner and safer you'll end up.

The Synchro nozzle valves are robust little units with a history of long, dependable service. However, debris or contaminants in your spray liquid will clog them. We recommend that 50 mesh strainers be installed in the spray lines up stream of the nozzle valves. *This is a critical step in installing your system.* Put the strainers as close as possible to the booms and the nozzle valves. Put them in a handy place so that you can easily and frequently clean them. Don't operate your Synchro system without these strainers. By the way, one thing we have found is that Teflon® pipe tape can easily lodge in the valve orifices and prevent proper opera-tion. This usually shows up in the first few hours of operation. Be careful as you install your fittings and avoid excessive tape on your threads.

Since the Synchro system allows you to electronically select your nozzles, you'll likely want to install new spray nozzles as you install your system. Read the chapter, "Selecting Nozzle Tips to Use With Your Synchro Blended Pulse System", get your new nozzles and have them ready to install as you install the nozzle valves. Usually, individual filter strainers before each nozzle are not needed with your Synchro System. Remember, you'll have those 50 mesh strainers upstream of the nozzle valves.

Before you start the installation is a good time to go ahead and remove any covers or panels that block access to your battery, rate controller connections or spray lines.

The installation of the system has three major parts: Installing the cabling, installing the nozzle valves and connecting the modules. We have found that it works well to have two people do the work. One person can run cables while the other installs the nozzle valves. When needed, the nozzle person can help the cable person.

So here is your sprayer prep checklist:

- ❑ 1. Make sure your rate controller is working properly.
- ❑ 2. Clean and thoroughly flush the spray lines; wash the sprayer.
- ❑ 3. Install 50 mesh filters upstream of your nozzle valves.
- ❑ 4. Select and buy your new nozzles.
- ❑ 5. Remove any access panels or covers that may block your work.

MOUNTING THE FLOW AND PRESSURE MODULES

The electronic modules are sealed units with the connectors securely potted. While they are rugged and reliable, we suggest that you mount your modules in the Synchro enclosure shown in Figure 8. Since you will be running all your connecting cables to the modules, you must decide where to mount your enclosure and modules before your start wiring.

You can mount your enclosure anywhere on your sprayer. We suggest that you select a place that is protected from accidents and impact. Your Synchro system is not designed to survive impacts with fence posts, nurse trucks or pry bars. Once installed and tuned to your system, you will seldom, if ever need access to the modules, so you can mount the module enclosure out of the way.

Secure the back plate of the enclosure to a sturdy structure on the sprayer. It is OK to drill additional holes on the back plate if needed. It is not OK to drill holes in your electronic modules.

You are now ready to begin wiring. We suggest that you do not actually secure your modules to the enclosure yet. You may need to access the back of the modules to adjust circuit board settings so just wait for now. As you run cables, make sure to leave enough slack so that they can enter the bottom of the enclosure cover. But don't leave so much slack that the cables can snag on moving parts or will prevent your enclosure cover from seating securely.

So your module mounting check list is:

- ❑ 1. Select mounting location for module enclosures.
- ❑ 2. Mount the back plate to a sturdy structure.
- ❑ 3. Do not mount the flow, slave and pressure modules yet.
- ❑ 4. Pay attention to the routing of your cables.

INSTALLING THE NOZZLE VALVES AND THE SYSTEM CABLING

So far, this has been pretty easy. Now let's do the hardest and slowest part. Each spray nozzle has its own Synchro valve. You'll install each of those valves and plug them into the daisy-chained cabling that runs along the boom. Look back at Figure 6 which shows how the Synchro flow and pressure systems install with the rate controller. Each connection requires a cable. Now it is time to install those cables.

One person can install the complete Synchro system. But, as we've said, installation goes more quickly with two or more people. One person can run cables while the others replace the spray nozzles and install the nozzle valves. Occasionally, a valve installer can give the cable person a hand in those tight spots.

Cabling: Route your cables using common sense. We suggest that you label your cables as you run them and check them off on the layout figures in the first section of this manual. Make a photocopy of the figures before you start and make your notes on the copies. Protect the cables near moving parts and secure them firmly. Remember to allow for the motion of folding, lifting and sliding booms. Protect the cables from being pinched or damaged. Extension cables are available for any of the Synchro cables. Once you have tested the system, you should secure the cables. We do recommend that you wait until you are sure the installation is correct and functional before you spend too much time securing cables. When you secure your cables, bundle them when possible and use cable ties to secure the bundles together and to firm structures on your sprayer. Note that battery power cables have in-line fuses. Mount them where they are accessible.

Nozzle valves: To install the nozzle valves, first make sure that you have TeeJet® ChemSaver® nozzle bodies. Note that the Synchro valves arecompatible with the plastic nozzle bodies. The brass ChemSaver® bodies are not compatible with Synchro valves since the check valve threads are different.

Installation goes faster, easier and is more pleasant if you first position the boom at a comfortable work level and drain all liquid from the boom. Then go along the boom and remove the diaphragm check valves from the nozzle bodies. Make sure that when you remove the check valve cover and spring that the Buna-N® or Viton® diaphragm is also removed from the nozzle body. Collect and save those parts in case you need to replace them later. This is a good time to also remove the spray nozzles that you will be replacing.

Then go back along the boom and screw the Synchro nozzle valves into the nozzle bodies where the check valves were removed. Be careful that the body o-ring and the nut o-ring are properly placed in each valve.

Figure 9 shows the components of the Synchro nozzle valve and the proper installation. Hand tighten the valve nuts for now. You will do a pressure test later and can tighten any of the valves that need it later. As you install the valves, you can also install the new spray nozzles. If you need help selecting a new nozzle, read the chapter, "Selecting Nozzle Tips to Use With Your Synchro Blended Pulse System".

The Synchro nozzle valves have a specially designed, 3-wire wiring harness that is hard-wired to automatically provide the alternate nozzle pulsing which blends the pattern. Note that each valve harness has a male and a female connector. Connecting them male-female along the boom takes care of the alternating. Do not alter the wires in the connectors. You will note that the white and green wires alternate along the boom. This is normal.

Since the boom sections are independent and may have even or odd numbers of nozzles, you may end up with adjacent nozzles on a boom being in the same "synch", that is, they pulse at the same time. This might affect the uniformity of coverage and spray overlap. If this is the case, then you can install the "nozzle alternator" to shift the even/odd pulsing. Just install the alternator cable between the cable from the flow module and the first nozzle valve on your boom section. The nozzle alternator cable simply changes the nozzle pulse command from the "even" to "odd" channel or vice-versa.

We recommend that you first install all the nozzle valves before you secure any of the cabling along the boom. Then, after you have tested your system and installation, go along and secure all the boom cables. Nylon cable ties work well for this. Be sure to allow enough slack for removing nozzle valves for service and for booms to fold, raise and vibrate without damaging any cabling. If you will be sliding your nozzles along the boom or otherwise changing spacing, be sure to allow enough slack but don't let the slack cable hang down where it might snag on any obstruction.

There is a plug to install on the final remaining daisy-chain wire on the last valve on each boom section. The plug prevents the exposed contacts from being shorted. Be sure to install these protective plugs on the ends of each section.

So, your cable and valve installation check list is:

- ❑ 1. Run your system cables to your rate controller and Synchro modules.
- ❑ 2. Make sure that you have plastic TeeJet® ChemSaver® nozzle bodies.
- ❑ 3. Remove the old spray nozzles and the diaphragm check valves.
- ❑ 4. Install the Synchro nozzle valves in the nozzle bodies.
- ❑ 5. Install your new spray nozzle tips.
- ❑ 6. Secure the cables after you have tested the system, not now.

MAKING THE CONNECTIONS TO YOUR RATE CONTROLLER AND DRY TESTING THE SYSTEM

Now you should have all the cables in place. If you haven't already, connect the system to

your rate controller as you laid it out in Step 1. But don't secure the modules to the enclosure back plate just yet. There are some internal switches and adjustments you may have to make to the circuit boards within your modules. If you need to do this, you'll have to remove the back plates and have access to the rear of the modules.

Your Synchro modules have been shipped from the factory set up for the most common installations and it is unlikely that you'll have to make internal adjustments right away. Note that the slave module for the flow system has no internal adjustments.

The flow module (the master, if you have slave units) has two internal adjustments: a "jumper" which accounts for the type of spray controller "servo" valve output signal and a bank of four slide switches which controls how fast your fast module responds.

Figure 10 shows the locations of the jumper and bank of switches. The jumper is just a little connector that connects two wires that extend from the circuit board. Note that the module is shipped from the factory with jumper installed. If your rate controller simply switches the polarity of the voltage applied to the pressure regulating valve, then make sure the jumper is installed. How do you know if your controller does this?

Look at the cable going to your electric pressure regulating "servo" valve. If you have 3 or 4 wires going to your valve and your spray rate controller is a Dickey-john®, then you will likely have to remove the jumper. If your cable going to the the valve has 2 wires and your rate controller is a Raven®, Micro-Trak®, Mid-Tech® or TeeJet®, then you should leave the jumper installed.

The bank of four switches sets the speed at which the flow module responds to the controller's command for more or less flow. Based on the switch settings as shown in Figure 10, you can control the time, in seconds, required for the flow module to change the duty cycle of the nozzle valves across the full range of flow - that is, from the maximum (full open) position to the minimum flow or vice-versa. The Synchro flow system is very fast - much faster than most motorized valves used by common rate controllers. So your rate controller may not be able to handle the speed of the Synchro flow system. We suggest that you start with your system set for a 4 second cycle time, as shipped from the factory. We'll explain more about optimizing your Synchro system performance in the last section on tuning your system.

The Synchro pressure module has six internal settings as shown in Figure 11. There are two jumper switches, a load resistor, a valve mode switch and two tuning dials.

There are two jumper switches on the board. Each jumper has two positions with each position connecting one of the outside pins to the center pin. The jumper switch J1 controls the action of the module. If your electric pressure regulating "servo" valve is installed in the by-pass configuration where it regulates liquid flow back to your tank, then set the switch in the "Run Only" position. This is the Number 1 position and how your module is shipped from the factory. If your electric pressure regulating "servo" valve is installed in the in-line configuration where it regulates liquid flow to the spray boom, then set the switch in the "Run/Hold" position. This is the Number 2 position and you must be sure to check it since it is not shipped from the factory in that position.

The jumper switch J2 controls the action of the automatic/manual functions of the module. This switch should almost always be set to the "Automatic/Manual" position (Number 2) and is shipped from the factory in that position. Contact Capstan if your application is not using the Capstan Synchro Cab Control Box or you do not want to use the manual control function of the pressure system.

There is a load resistor, R24 on the circuit board. If you have a Case Tyler OEM installation, this resistor will be clipped out. Otherwise, if you are using the Capstan Synchro Cab Control Box the resistor should be left in the circuit.

There is a bank of four small switches on the circuit board. Switches #1, #2 and #4 are not used. Switch #3 selects the module's output for driving your pressure control valve. Almost all sprayer valves are two-directional (sometimes called "bipolar") This means that the valve motor is rotated in two directions such as "open" and "closed". In the bipolar setting, which is the default switch setting of "off", the module reverses the polarity of the output voltage to open or close the valve. This is how all common electric pressure regulating valves (Raven®, KZ®, Mid-tech®, Micro-trak®, TeeJet®)work.

If you are using an electric drive pump or you have a custom hydraulic control valve, you may use the unipolar (J3 Switch #3 in "on" position) to force the module output signal to a 12Vdc PWM output. Consult your Capstan dealer for more details on these applications.

There are two speed control dials for setting up how your Synchro pressure control system responds. The upper dial, P2, sets the "settling time" for your Synchro pressure controller. This is how much "hunting" you want to allow the pressure to do. To decrease the settling time, that is, to make the system more sensitive, turn the dial clockwise. We suggest that you begin with the dial set about 50% open. The entire span of the dial is about 3/4 turn, so to find an approximately 50% setting, turn it to one stop, then all the way to the other stop and then return to about 1/2 way between them. The upper dial, P1, sets the response speed for your Synchro pressure controller. This is how fast the pressure module will attempt to open or close your pressure regulating or "servo" valve. Remember, the Synchro pressure control can only be as fast as your electric pressure regulating valve. You may have to adjust your P1 and P2 switches to balance the operation of your system. Often a fast system can become unstable when you make rapid changes while a slow system can be very sluggish to respond to your commands. We suggest that you set the P1 switch about halfway in its range of motion. You can adjust or "tune" your entire system once you have it running. That will be the last step in your installation.

The dry run: At this point, we suggest you dosome preliminary testing of your wiring. With no liquid or pressure on the system (you don't even need the engine running), you can turn on your system and make sure the power and valve wiring is correct. When powered up, and receiving no input flow command (into the "servo" connector input), your Synchro flow control module outputs a 50% flow signal to all valves. You can always unplug the "servo" valve input to the module and cycle the power by unplugging and replugging the power input cables. That should "wake up" the module at 50% duty cycle.

So power up your rate controller and turn on a boom section. Start with the boom sections on your master flow module if you have slaves installed. You should hear and feel the valves on the selected boom section begin to click when you turn on a boom section. Every valve on that section should click. Try each boom section individually.

Troubleshooting the installation: If a boom section does not click, then check to see that you have properly connected that section to your flow control module (master or slave). Verify that all cables, including extensions, are securely connected. Then verify that your boom shut-off wires are properly connected to both the Synchro modules and your spray rate controller. Make sure the rate controller is powered on and that the boom shut-off switches are in the "spray on" position. Also, make sure that you have power to your modules. Check the powerline fuses. Check the output fuses for each boom section. If the boom section is still not clicking, then try plugging the boom section cable into a different boom channel on your flow control module. If the boom clicks when plugged into a different boom section connector, make sure that your boom-shut off wiring is correct and recheck the output fuses. If the boom section does not work when connected to a different boom output connector, check the cables to the boom and the power to the modules. Do not proceed further until you can get all the nozzle valves to click. Use the same procedure to make sure that your slave modules, if installed, are working properly.

Now is the time to check and make sure that your booms are controlled by the proper shut-off switch on your controller. Turn on your booms one at a time and confirm that the boom locations correspond to your switches. If they don't, usually you need only to swap out some of the boom output connections. That is, unplug the boom cables from the module and try them in different module output connectors until you get your desired action.

If one of your boom sections does not work or if the fuse for one section keeps blowing, then you may have a short in the wiring. To diagnose this, unplug the cable (which runs from the master or slave flow module to the boom section) from the first valve on the boom. If the fuse keeps blowing, then your short is in the cable between the module and the boom. If not, then unplug each nozzle valve from one another all along your boom section. Then start at the cable coming from the module and begin adding the nozzle valves one at a time by plugging them in. As you plug in each valve, it should begin to click. When you plug in one which does not click or one which blows the fuse, then you have located the faulty valve, cable or connector.

Test your connections of the Synchro pressure control module by placing the power switch in the manual mode. Use the increase/decrease switch to open or close the electric pressure regulating valve. On valves with a position indicator, such as KZ® valves, you will be able to see the valve motion. If your valve does not have a position indicator, you may be able to feel the valve being activated. On some valves, you can remove a cover plate or the motor assembly to see the valve operation. If the valve moves in a direction opposite your intended adjustment, then reverse the cables going to the valve.

Now, you are ready to fill your spray tank with clean water and begin your Synchro experience. That is covered in the next section.

So your controller connection and dry run check list is:

- ❑ 1. Verify that you have run all the necessary cables.
- ❑ 2. Check to see if your installation is the typical "default" configuration and requires no changes in the internal setting of the modules.
- ❑ 3. If you need to make changes in the internal settings of the modules, remove the back panels and make the changes.
- ❑ 4. Verify the proper internal settings before you replace the back cover. (You might want to wait until you are done with the dry run and tuning the system to replace the cover.)
- ❑ 5. Power up your spray rate controller and flow system and do a dry run to make sure you have valves on all the boom sections clicking, that the boom section shut-off signal work properly and that your boom control switches on your rate controller match the proper boom sections. Troubleshoot if operation is not correct.
- ❑ 6. Power up your pressure system, enter the manual mode and test to make sure that the pressure adjust switch activates the pressure regulating valve. Troubleshoot if operation is not correct.

TUNING THE SYSTEM WITH YOUR RATE CONTROLLER AND WET TESTING

Here's the moment you have been waiting for. Let's spray!

If you haven't already, flush your system with clean water and remove any traces of pesticide from your tank. Remove the nozzle valves to drain the system. Refill with clean water.

Now, let's talk a moment about adjusting the settings on your rate controllers. **First, make sure you run your controller in the flow-based mode.** Some controllers allow pressure or flow based control or use a combination of both. The Synchro system works only with flow-based rate control. Remember, pressure (and droplet size) are controlled separately. Also, most controllers allow you to adjust the speed of pressure valve operation, electronic braking of the valve, minimum and maximum acceptable errors and minimum and maximum application rates. While each situation is different, Capstan suggests the following general guidelines:

Do not use electronic braking. Remember, your rate is not controlled by a pressure valve but by a very fast duty cycle controller.

Set your valve speed to a moderately fast rate. The Synchro system can respond quickly. Set your minimum application rate very low. Remember that the Synchro system has a very wide range of control. You do not have to worry about poor patterns at low flow rates.

Our experience has shown that there are some controller settings that work well. For example, most Raven® controllers perform

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well with the Synchro systems when a "Valve Cal" = 42 is used. Contact Capstan for more information if you are interested.

Turn on your spray rate controller and enter the test mode which lets you spray different rates with various simulated ground speeds. Set up your rate controller for a middle range of your typical spraying by entering a normal application rate and ground speed. Assume you will spray at your normal liquid pressure. Use your nozzle catalog to verify that the nozzles you have installed have a spray capacity greater than your test conditions. For example, if your normal conditions are 24 gal/acre, 40 psi pressure and 5 mph ground speed, you'd probably use 0.4 gpm nozzles (8004 maybe) for your application. With the Synchro system, you'd probably change those to 0.6, 0.8 or 1.0 gpm nozzles (8006, 8008 or 8010 maybe).

Turn on your spray booms. You should see the valves begin to pulse. Some of the valves may leak or appear to be stuck open or closed. Leaking valves can usually be fixed by tightening the nut that holds them to the nozzle body. If not, remove the nozzle valve and make sure the o-rings are in proper position and tighten the nut. Occasionally, a nozzle body may be worn or deformed such that the nozzle valve cannot seat properly. In that case, replace the TeeJet® ChemSaver® nozzle body. Valves that are stuck open or closed should be disassembled and clear of debris. Be sure to properly seat the o-rings when re-installing them.

Once in operation, the spray system should eventually settle to the rate you have programmed. For now, use the Synchro pressure regulating system in the manual mode and adjust the pressure to your typical operating pressure. We will not test it until we are sure that the flow system is working properly. We'll test one thing at a time.

If your valves are not pulsing but all of them appear to be stuck open, then reduce your application rate or your test speed on the controller. Again, make sure that you are within an application rate range that is possible using your speed, pressure and nozzle tip. If by reducing your rate you still cannot get the nozzles to pulse, you may have the polarity reversed on your spray rate controller connection to the"servo" input on the flow module. In that case, the controller is driving the valves to the full open position when you attempt to reduce flow rate. Try installing the Valve Input Polarity Adapter or otherwise reversing your input cables.

Once you have your valves pulsing, use your rate controller panel controls to adjust your application rate (gallons per acre) and ground speed over a wide range. Notice the wide range of control you have. It is normal to see some pressure fluctuations during this testing. Since your pressure valve is in a fixed position, as you vary flow, you are changing the pressure drop through your system.

If your response is sluggish, you can increase the valve speed on your rate controller and/or decrease the cycle time of the Synchro flow system (using the switches on the circuit board in the master flow module). You can also now use the manual pressure control switch to adjust the spray pressure and see how the flow system restores your application rate right back on target.

Once the flow system is working well, let's try the pressure system. With the flow controller set for a middle range of application, move your pressure system switch from manual to automatic. Now alter the applica-

tion rate and ground speed and see how the system quickly settles on your correct application rate and the pressure you have selected. Use the two-position switch to set two ranges of pressure. Toggle between them and see how the pressure system responds to changes. If the response is too slow or fast, then adjust the speed setting, P1, on the pressure module circuit board. If the pressure overshoots or never quite reaches your settings, then adjust the P2 switch in the module.

System tuning is adjusting the response times of your components so that your spraying changes are quickly corrected by the system but without excessive hunting or instability. Since the flow module and pressure modules, along with your rate controller all allow their response to be adjusted, you may need to experiment with settings and changes in order to get your system operating ideally for your particular sprayer and spraying conditions.

If your system does not respond or simply goes to maximum or minimum pressure and then stays there, it is likely that your output polarity to the pressure regulating "servo" valve is reversed. In that case, reverse the wire going to your electric valve.

Once you are satisfied with your system performance, close the module covers, secure the modules in the enclosure and secure any loose cabling. Your Synchro Blended Pulse Spraying System is ready to work!

So your wet testing and tuning checklist is:

- ❑ 1. Select a middle range of spray conditions and program them into your rate controller. Enter the test mode so you can spray while parked.
- ❑ 2. Verify that you have the proper "oversized" nozzle.
- ❑ 3. Start your sprayer and check the operation of the nozzle valves. Adjust and re-seat if needed.
- ❑ 4. Set the pressure system in manual mode at a typical spray pressure.
- ❑ 5. Adjust your spray conditions (rate, speed) to test the response of the flow control system.
- ❑ 6. Adjust the response time of your flow module and rate controller if needed.
- ❑ 7. Place the pressure system in the automatic mode and set your pressures for toggling.
- ❑ 8. Adjust your pressure and verify that the flow module and rate controller restore the application rate over a wide range of pressure.
- ❑ 9. Adjust the response time and sensitivity of the pressure module if needed.
- ❑ 10. Secure the module covers, secure the modules in the enclosure and secure any loose cables.

At this point, your system is ready to go. Welcome to the future of spraying!!

For convenience, here are your check lists summarized. You may want to make a copy to mark on.

System planning and layout checklist:

- ❑ 1. Read this section of the manual; understand how the Synchro system works.
- ❑ 2. Verify that you have sufficient electrical power for all the valves and accessories. Upgrade your alternator if needed.
- ❑ 3. Install your rate controller and make sure it works properly.
- ❑ 4. Unpack and lay out the parts and components for your system.
- ❑ 5. Make sure you have all the correct cables and connectors.
- ❑ 6. Lay out your Synchro flow module and connections.
- ❑ 7. Layout your Synchro slave flow modules, if used.
- ❑ 8. Determine how you will control pressure; lay out the Synchro pressure module.

Sprayer prep checklist:

- ❑ 1. Make sure your rate controller is working properly.
- ❑ 2. Clean and thoroughly flush the spray lines; wash the sprayer.
- ❑ 3. Install 50 mesh filters upstream of your nozzle valves.
- ❑ 4. Select and buy your new nozzles.
- ❑ 5. Remove any access panels or covers that may block your work.

Module mounting checklist :

- ❑ 1. Select mounting location for module enclosures.
- ❑ 2. Mount the back plate to a sturdy structure.
- ❑ 3. Do not mount the flow, slave and pressure modules yet.
- ❑ 4. Pay attention to the routing of your cables.

Cable and valve installation check list:

- ❑ 1. Run your system cables to your rate controller and Synchro modules.
- ❑ 2. Make sure that you have plastic TeeJet® ChemSaver® nozzle bodies.
- ❑ 3. Remove the old spray nozzles and the diaphragm check valves.
- ❑ 4. Install the Synchro nozzle valves in the nozzle bodies.
- ❑ 5. Install your new spray nozzle tips.
- ❑ 6. Secure the cables after you have tested the system, not now.

Controller connection and dry run check list:

- ❑ 1. Verify that you have run all the necessary cables.
- ❑ 2. Check to see if your installation is the typical "default" configuration and requires no changes in the internal setting of the modules.
- ❑ 3. If you need to make changes in the internal settings of the modules, remove the back panels and make the chances.
- ❑ 4. Verify the proper internal settings before you replace the back cover. (You might want to wait until you are done with the dry run and tuning the system to replace the cover.)
- ❑ 5. Power up your spray rate controller and flow system and do a dry run to make sure you have valves on all the boom sections clicking, that the boom section shut-off signal work properly and that your boom control switches on your rate controller match the proper boom sections. Troubleshoot if operation is not correct.
- ❑ 6. Power up your pressure system, enter the manual mode and test to make sure that the pressure adjust switch activates the pressure regulating valve. Troubleshoot if operation is not correct.

Wet testing and tuning check list:

- ❑ 1. Select a middle range of spray conditions and program them into your rate controller. Enter the test mode so you can spray while parked.
- ❑ 2. Verify that you have the proper "oversized" nozzle.
- ❑ 3. Start your sprayer and check the operation of the nozzle valves. Adjust and re-seat if needed.
- ❑ 4. Set the pressure system in manual mode at a typical spray pressure.
- ❑ 5. Adjust your spray conditions (rate, speed) to test the response of the flow control system.
- ❑ 6. Adjust the response time of your flow module and rate controller if needed.

- [ ] 7. Place the pressure system in the automatic mode and set your pressures for toggling.

- [ ] 8. Adjust your pressure and verify that the flow module and rate controller restore the application rate over a wide range of pressure.

- [ ] 9. Adjust the response time and sensitivity of the pressure module if needed.

- [ ] 10. Secure the module covers, secure the modules in the enclosure and secure any loose cables.

7. Installation Drawings & Photos

This section contains all of the drawings and photos which are referenced throughout this manual:

Spray Rate Controller used with in-line pressure regulating valve & centrifugal pump 7-3

Spray Rate Controller used with by-pass pressure regulating valve & centrifugal pump 7-5

Connecting the Synchro Flow Control Module and Synchro Nozzle valves to controller 7-7

Detailed connections and pin-out of the Synchro Flow Control Module 7-9

Wiring connections for adding Synchro Slave Flow Control Module 7-11

Detailed connections and pin-out of the Synchro Slave Flow Control Module 7-13

Wiring connections for adding the Synchro Pressure Control Module 7-15

Run/Hold connections between Synchro Flow Control and Pressure Control Modules 7-17

Detailed connections and pin-out of the Synchro Pressure Control Module 7-19

Mounting plate, enclosure and modules 7-21

Synchro nozzle valve assembly 7-23

Internal switch locations/settings for Synchro Flow Control Module 7-25

Figure 1a. - A typical spray rate controller used with an in-line pressure regulating (sometimes called a "servo" or "throttling) valve and a centrifugal pump.

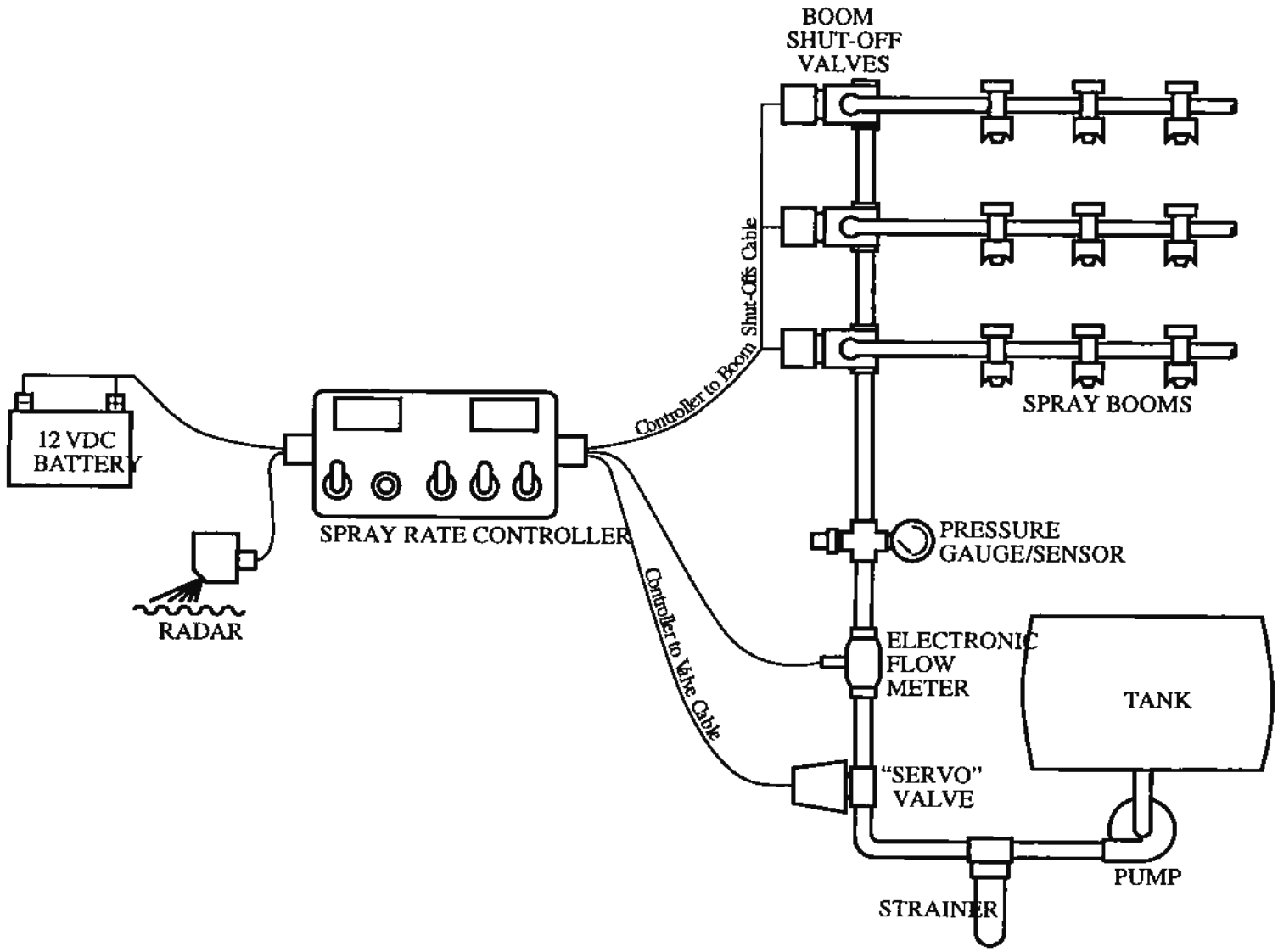


Figure 1b. - A typical spray rate controller used with a by-pass pressure regulating (sometimes called a "servo" or throttling") valve and a centrifugal pump.

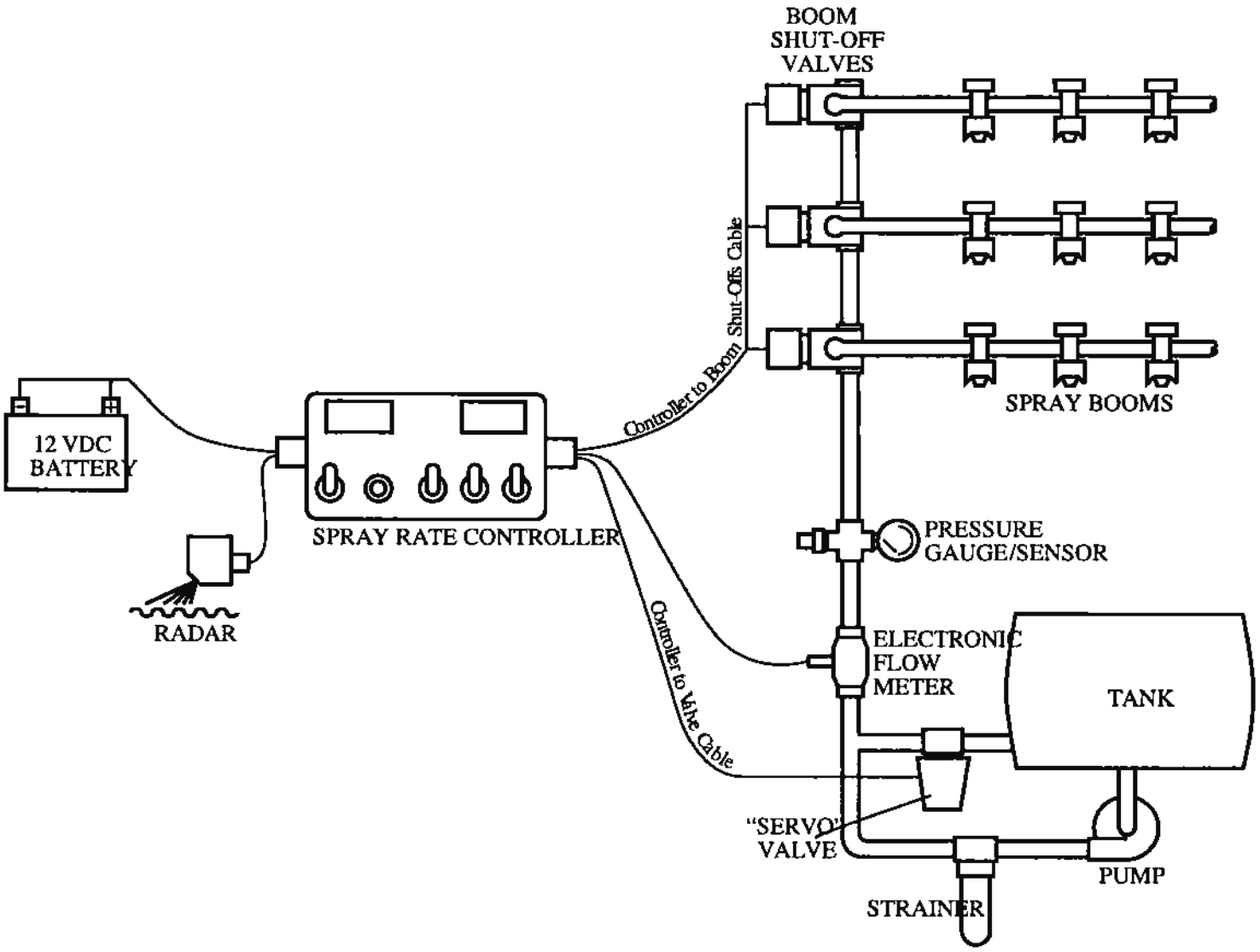


Figure 2. - Connecting the Synchro Flow Control Module and the Synchro Nozzle valves to your spray rate controller. This figure shows the flow rate control system. Pressure control options are discussed later.

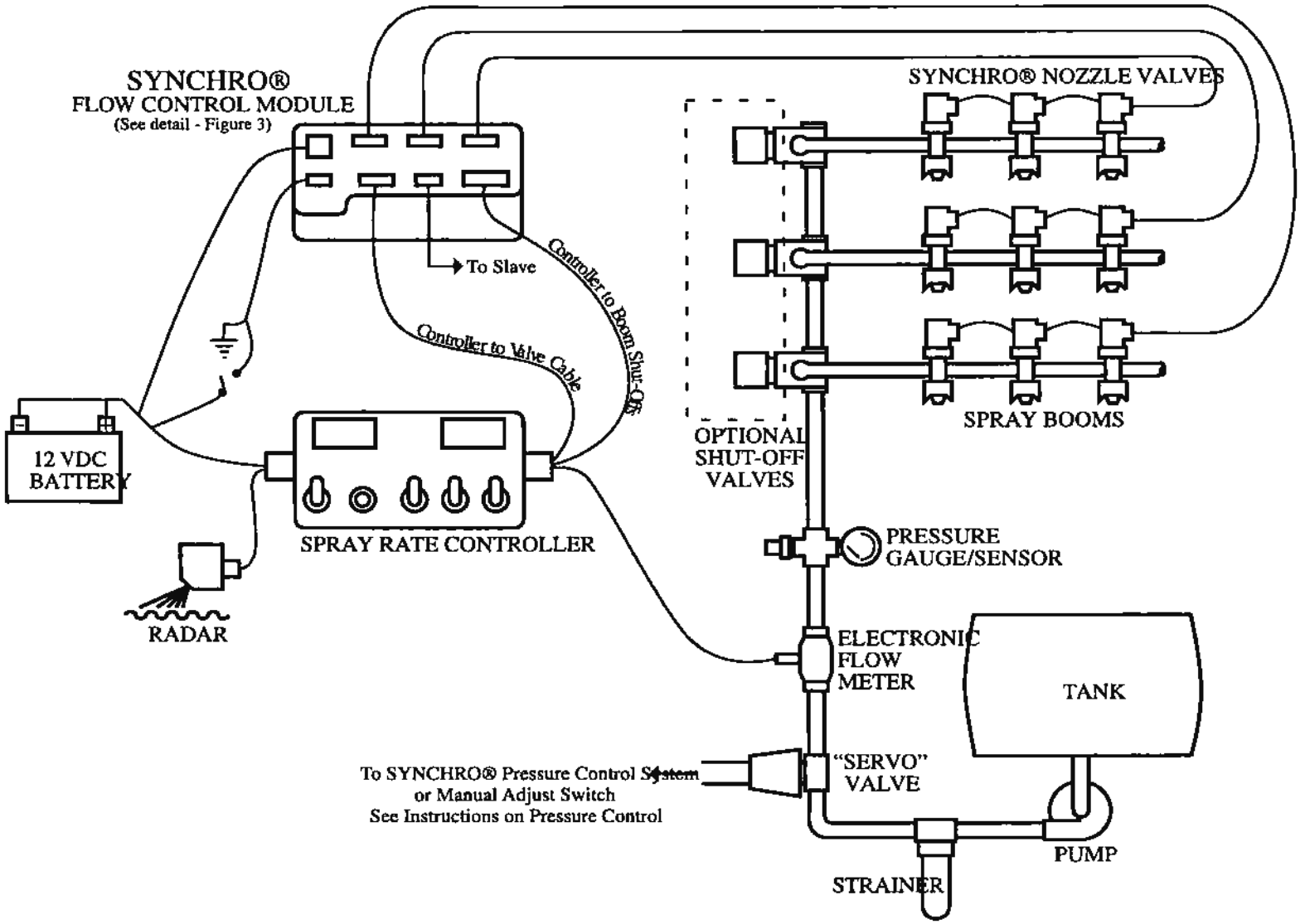
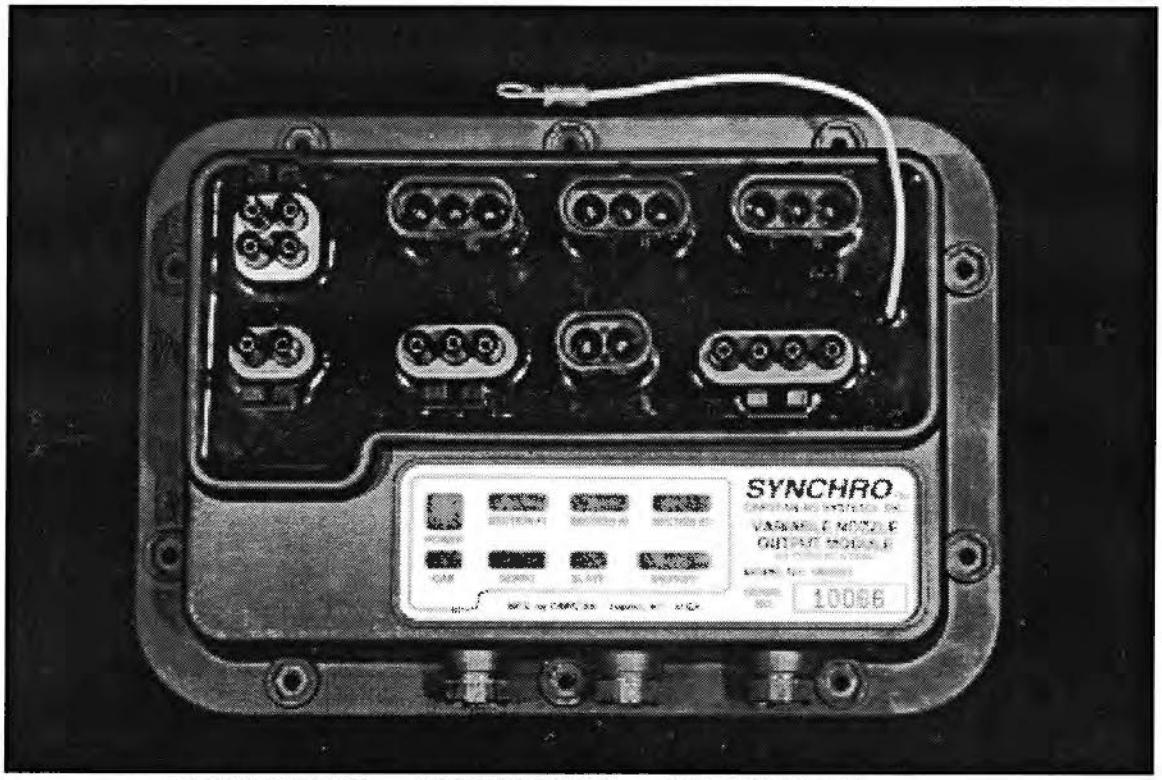
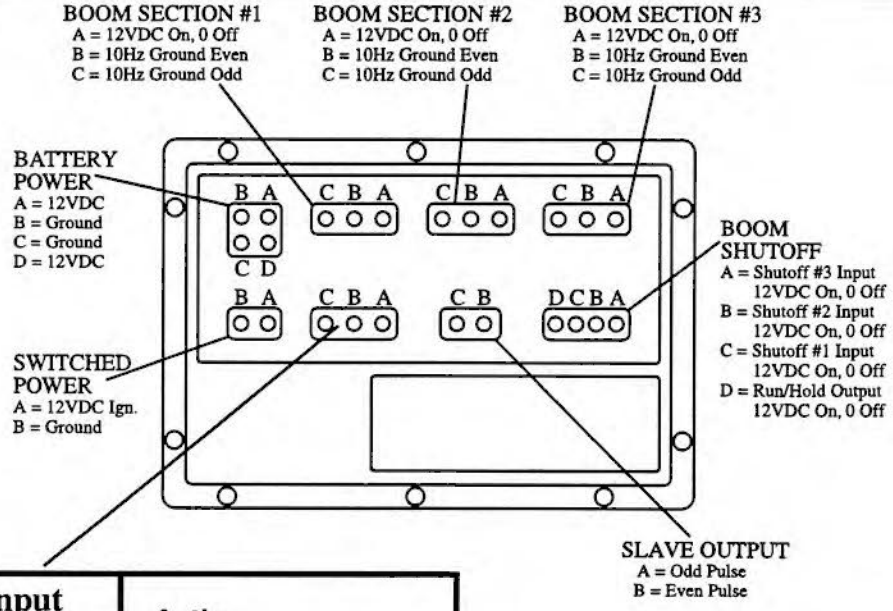


Figure 3. - Detailed connections and "pin-out" of the Synchro Flow Control Module. This is the front view and the label is in the position we'll call the "lower right" of the module. If you will be using "slave" modules, then this is your "master" module.





Servo Input			Action
A	B	C	
UNUSED	12V	GND	INCREASE FLOW
	GND	12V	DECREASE FLOW
	GND	GND	NO CHANGE
	12V	12V	NO CHANGE

Figure 4. - Wiring connections for adding the Synchro Slave Flow Control Module to the system. Slave modules can be daisy chained, that is, strung together, with as many as needed.

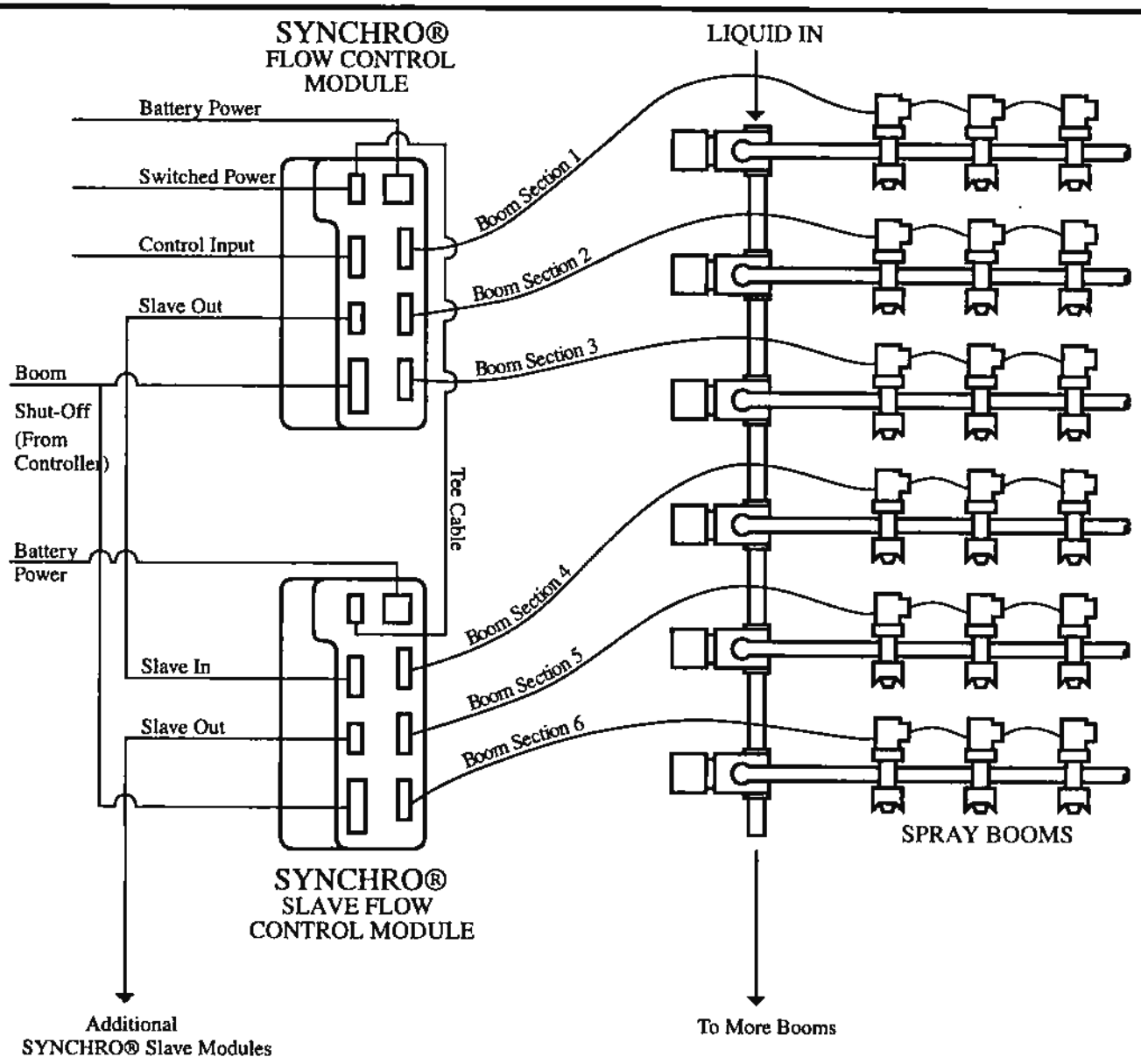
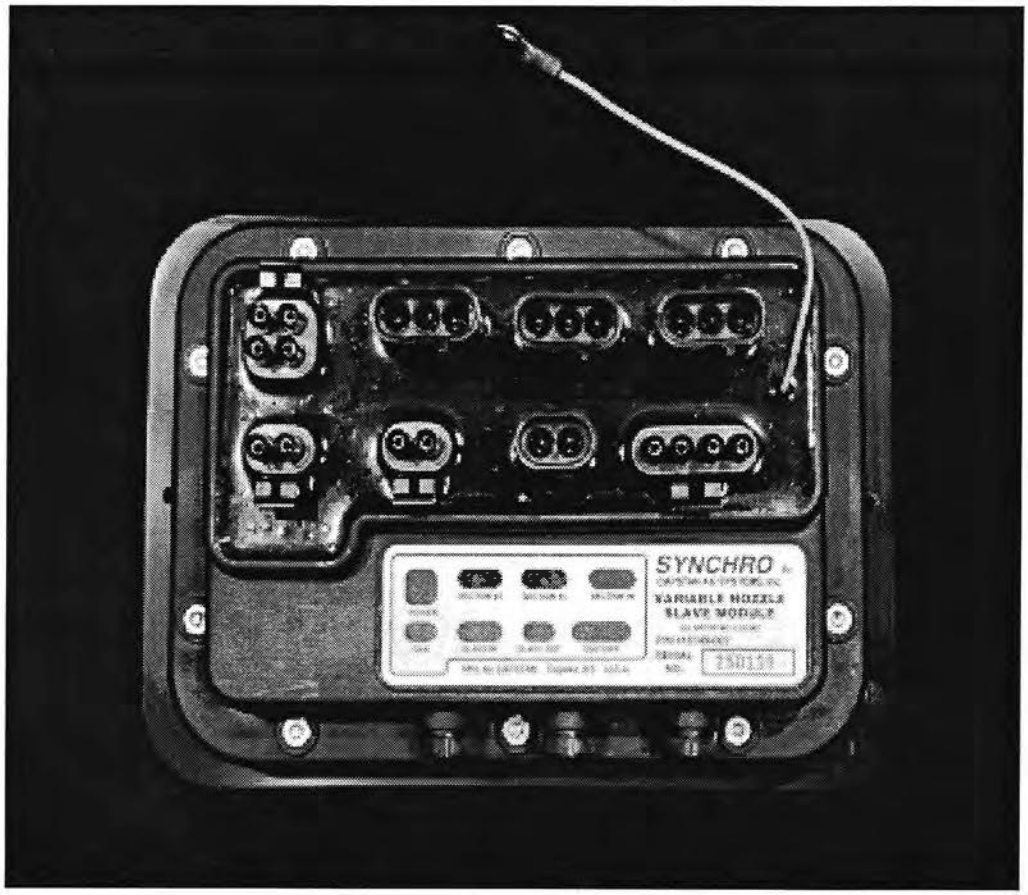


Figure 5. - Detailed connections and "pin-out" of the Synchro Slave Flow Control Module. This is the front view and the label is in the position we'll call the "lower right" of the module.



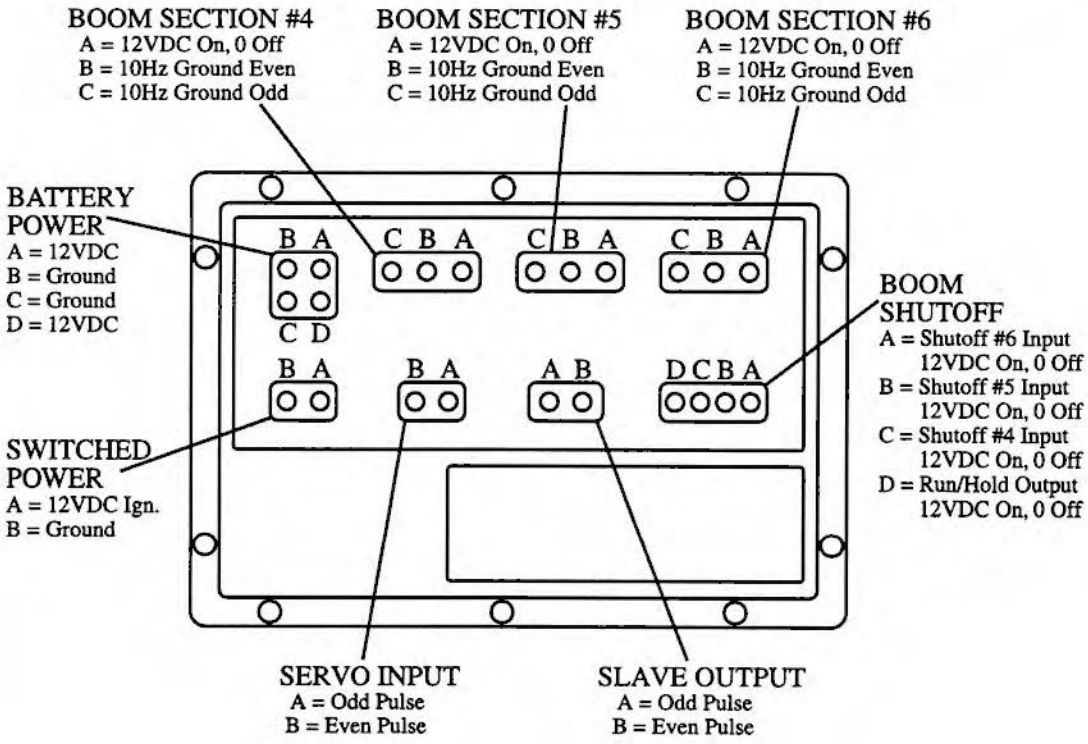


Figure 6. - Wiring connections for adding the Synchro Pressure Control Module, Synchro Cab Control Box and Synchro Pressure Sensor to the flow control system.

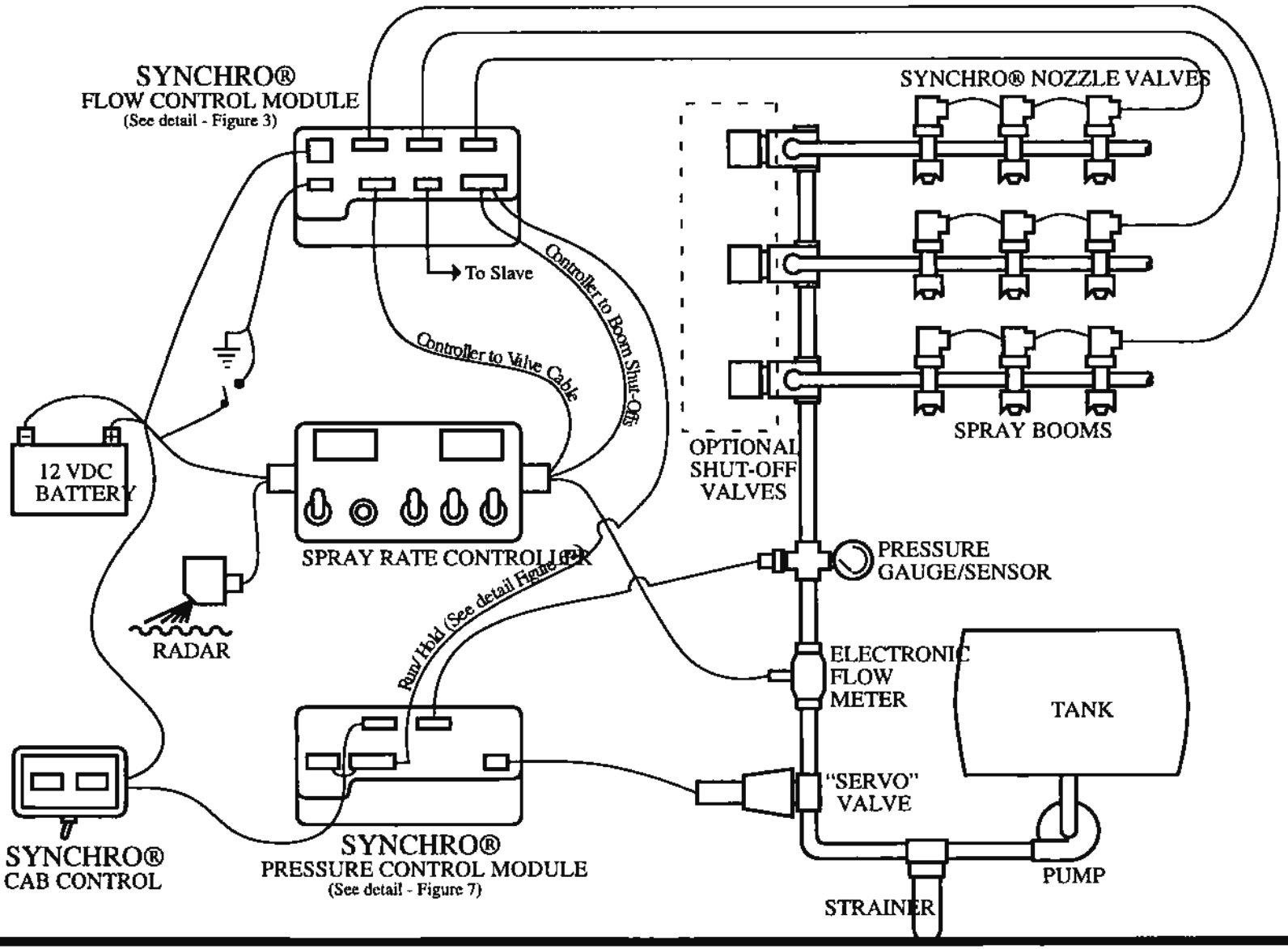


Figure 6a. - Details of Run/Hold connections between Synchro Flow Control Module and Pressure Control Module.

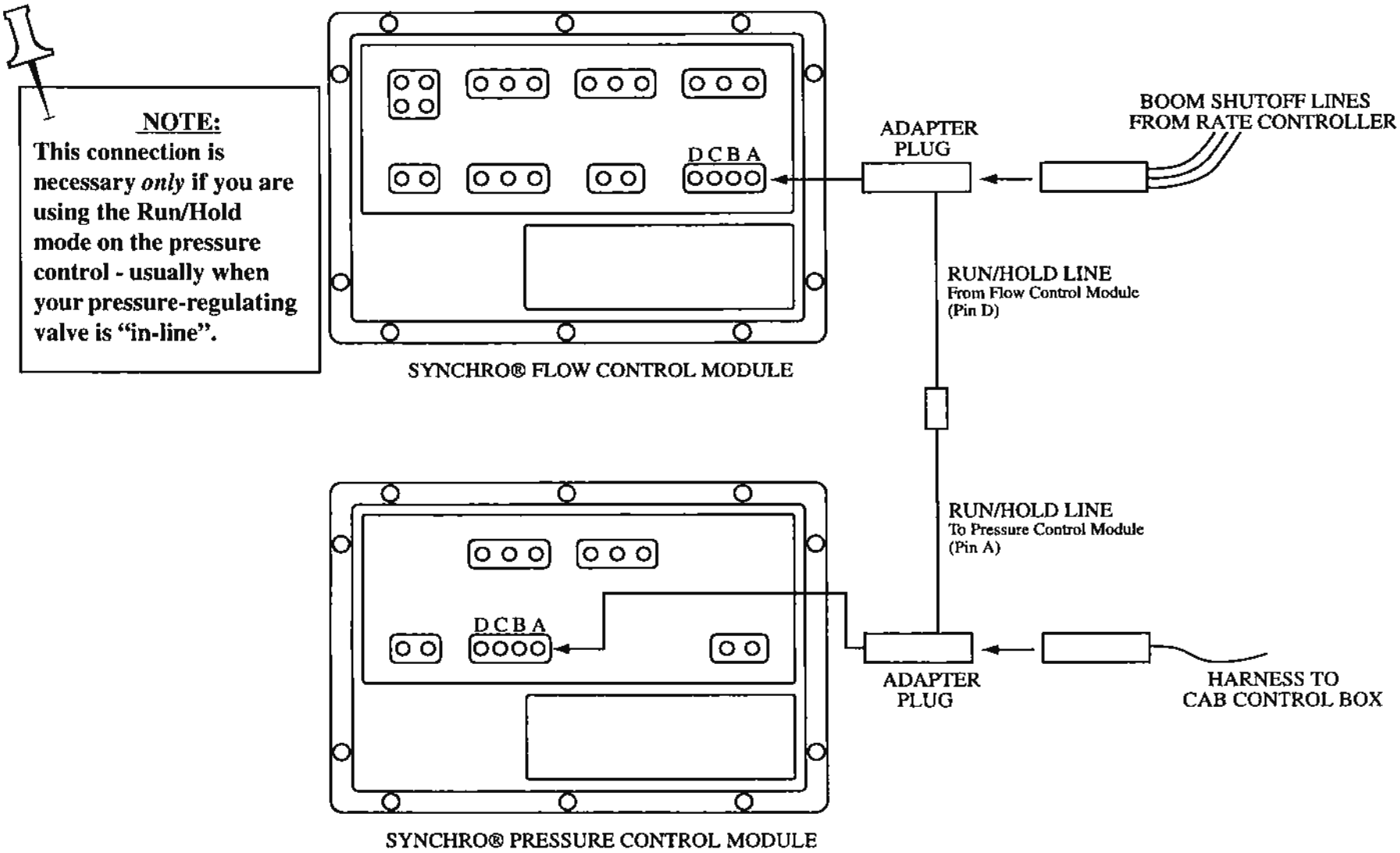
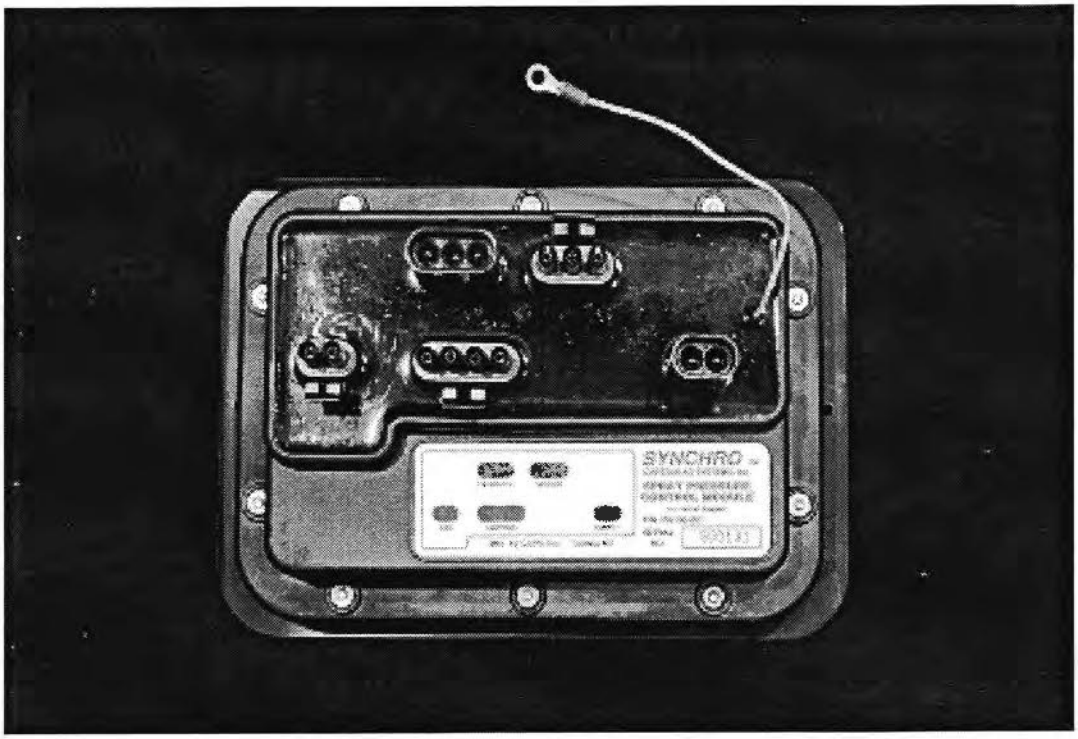


Figure 7. - Detailed connections and "pin-out" of the Synchro Pressure Control Module. This is the front view and the label is in the position we'll call the "lower right" of the module.



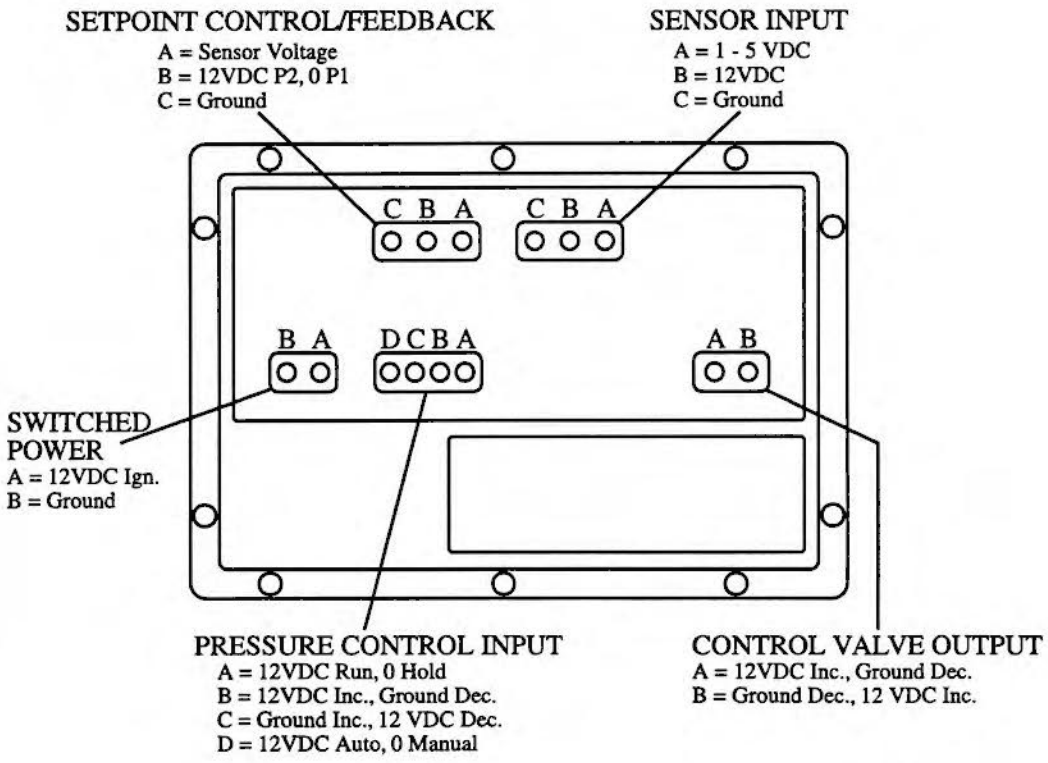


Figure 8. - The mounting plate, enclosure cover and modules for the Synchro System.

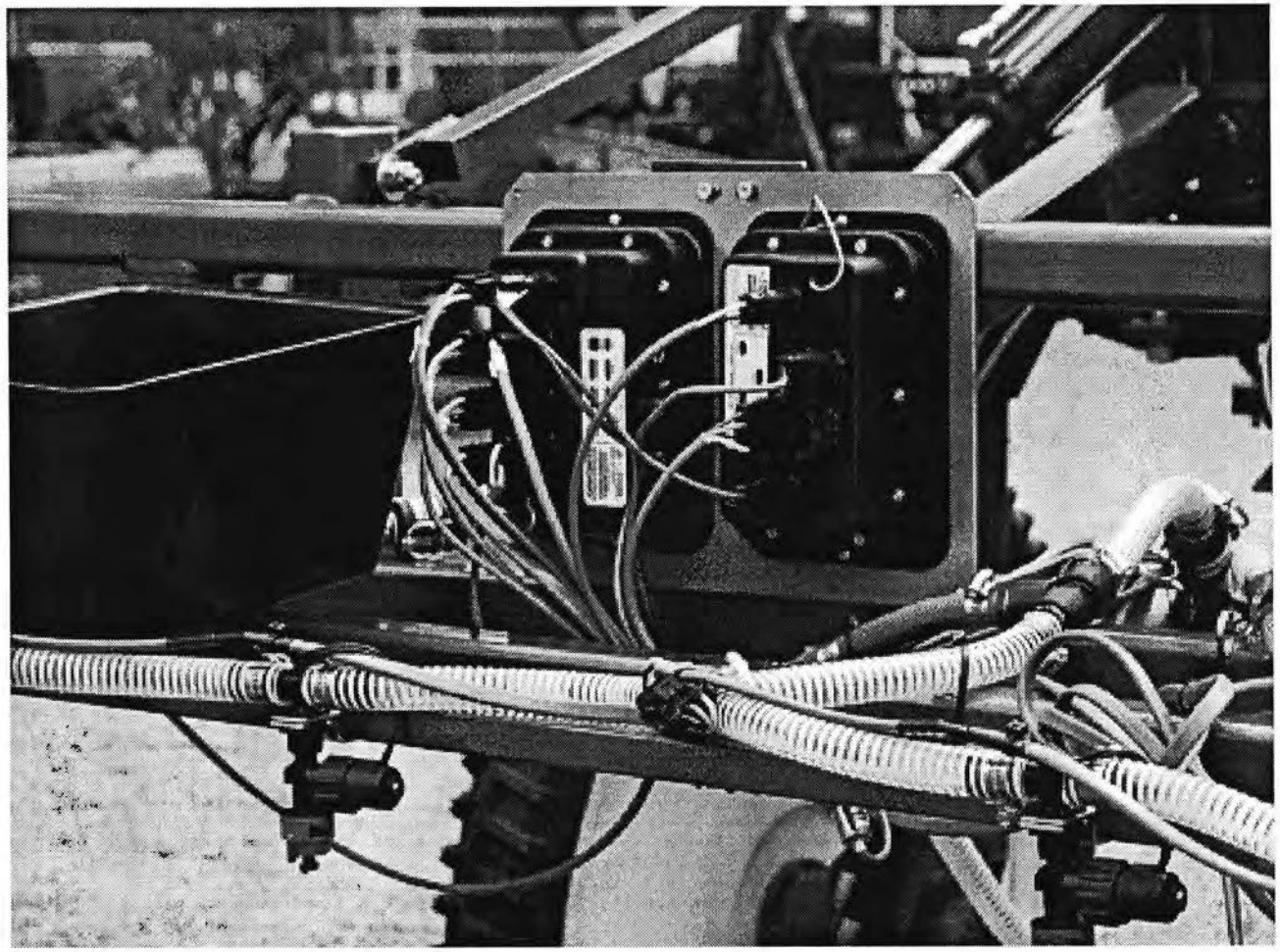
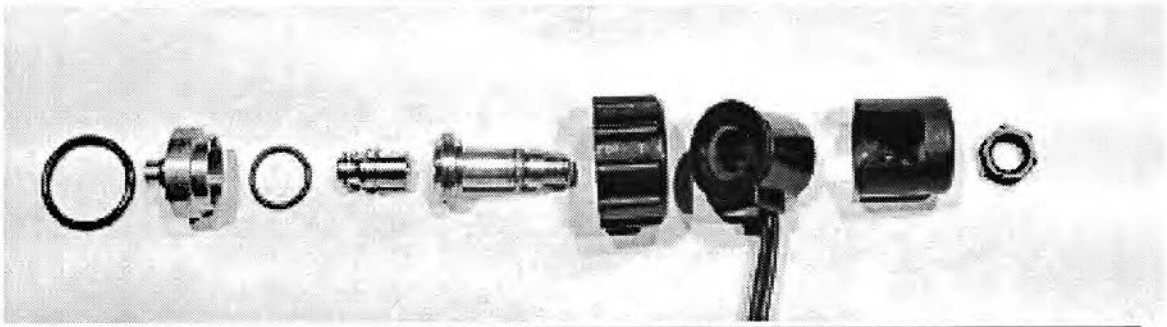
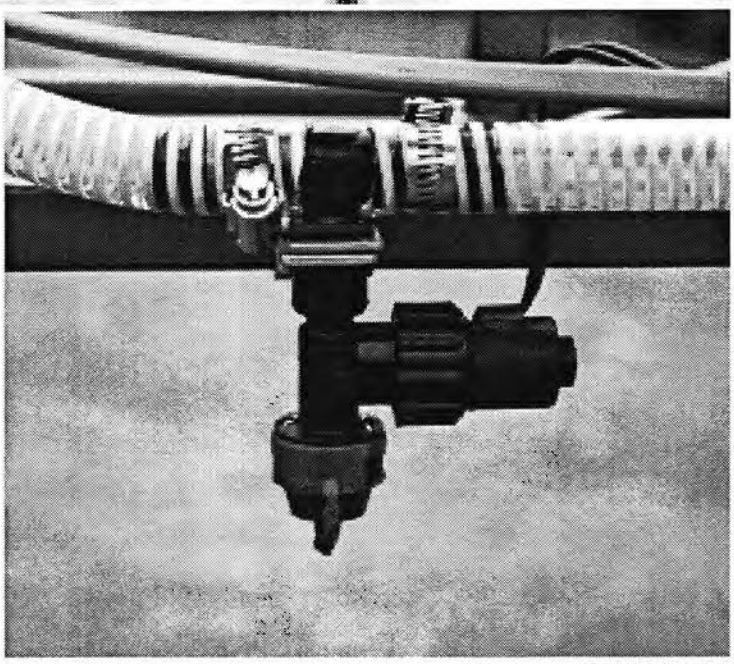


Figure 9. - The Synchro Nozzle Valve assembly.





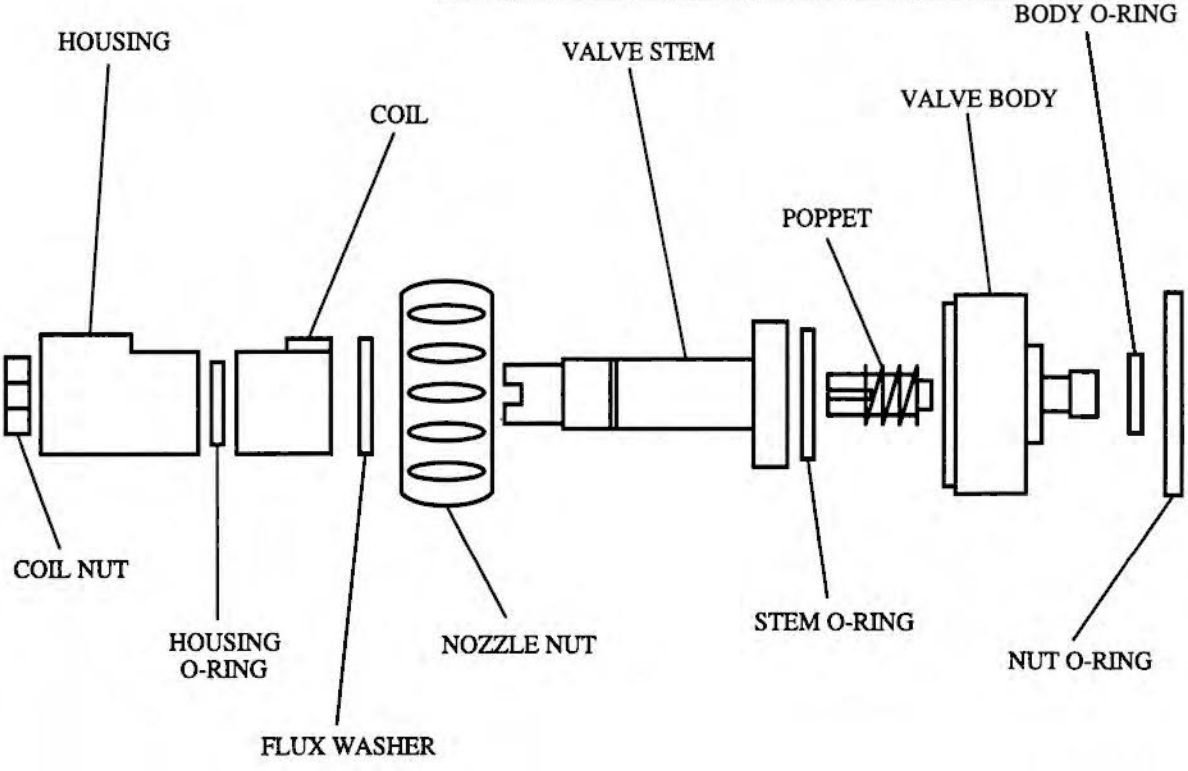
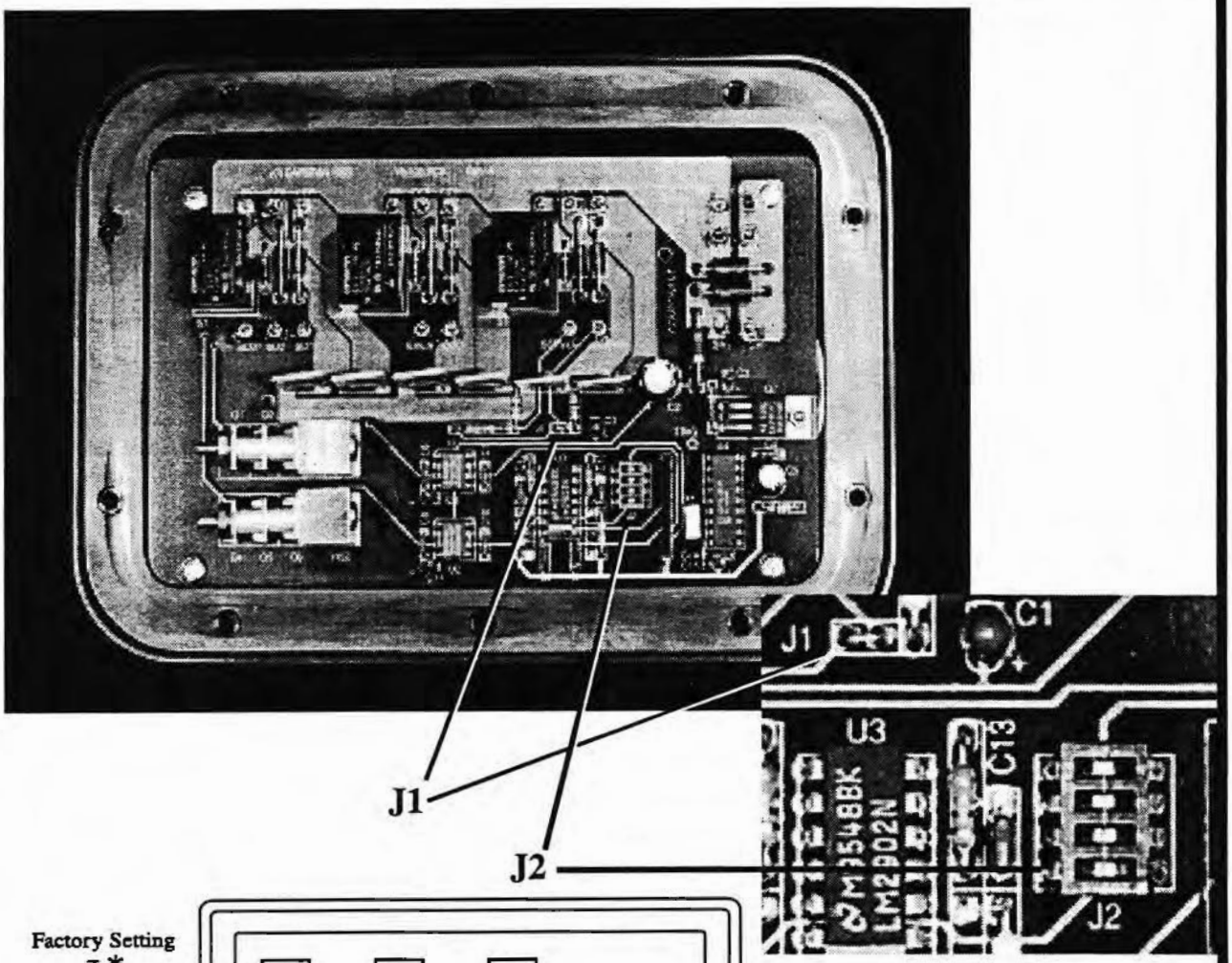
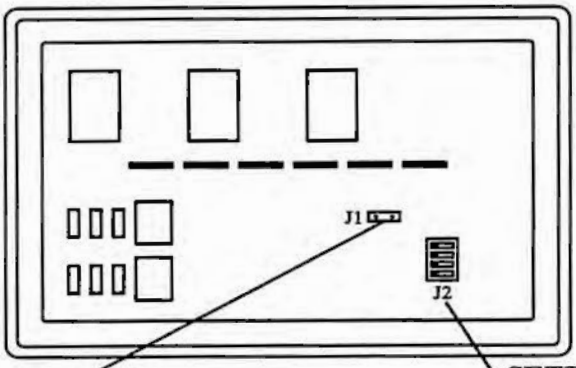


Figure 10. - The internal switch locations and settings for the Synchro Flow Control Module.



Factory Setting
= *



INPUT JUMPER J1

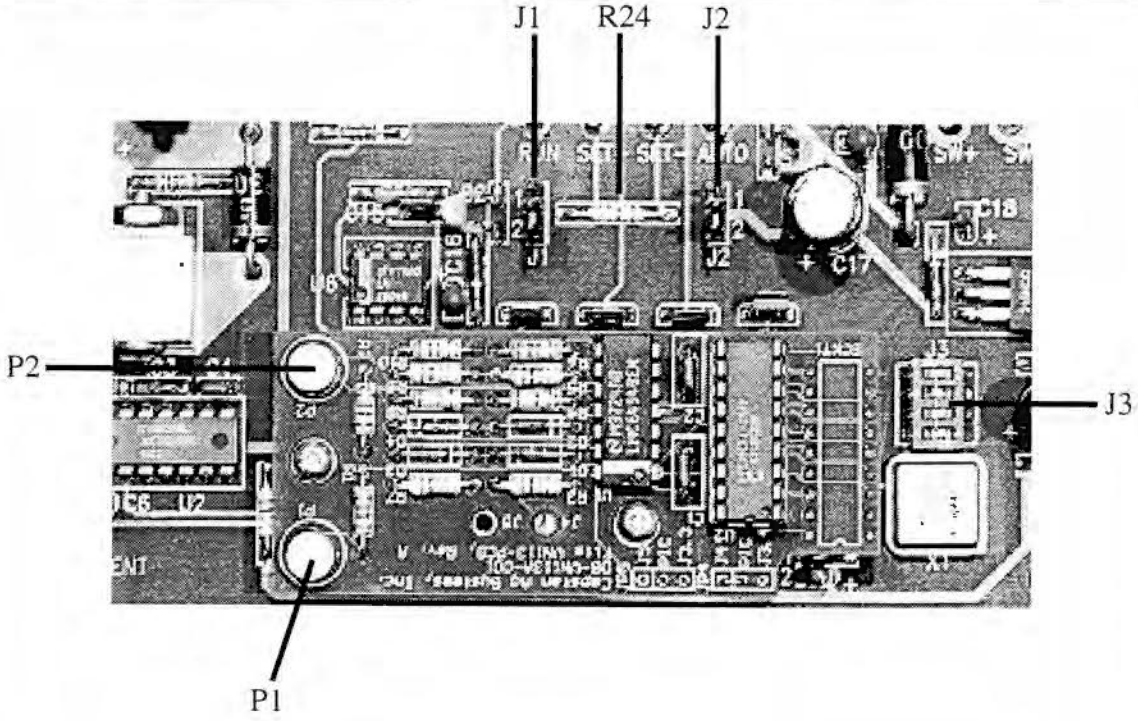
*Install Jumper J1 If:
Spray Controller provides power and ground to the control valve, and switches polarity to change directions.
(Typically: Raven, Mid-Tech, TeeJet, Micro-Trak)

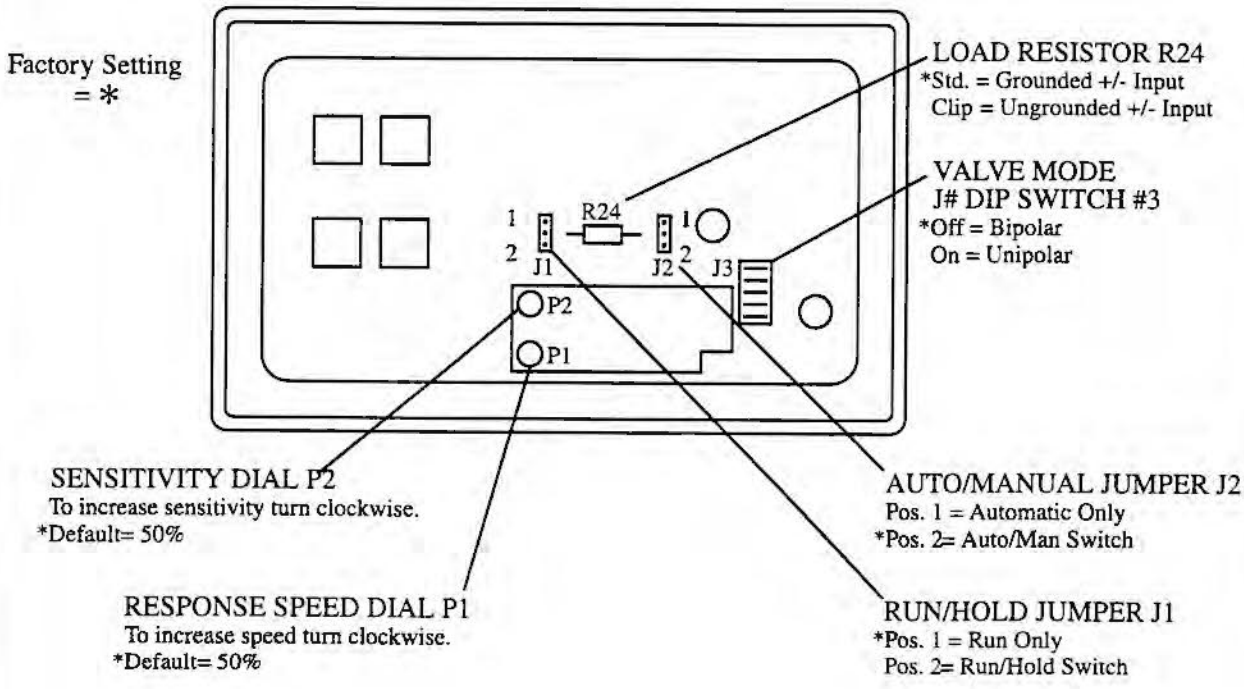
Remove Jumper J1 If:
Spray Controller does not provide ground.
(Typically: Dickey-john)

SETTINGS FOR SPEED OF CHANGE

	SW1	SW2	SW3	SW4	SEC
	OFF	OFF	OFF	OFF	1.0
	OFF	OFF	OFF	ON	2.0
	OFF	OFF	ON	OFF	3.0
*	OFF	OFF	ON	ON	4.0
	OFF	ON	OFF	OFF	6.0
	OFF	ON	OFF	ON	8.0
	OFF	ON	ON	OFF	10.0
	OFF	ON	ON	ON	12.0

Figure 11. - The internal switch locations for the Synchro Pressure Module.





8. Trouble Shooting Your Synchro® Blended Pulse System

Your Synchro system has been designed to operate over a wide range of spraying conditions and to provide dependable service. If you do have problems, remember that the Synchro system is just *part* of your sprayer and any problems with your rate controller or other spray system components may only appear to the problems with the Synchro system.

If you have **just installed your Synchro system** or received delivery of a new sprayer with a Synchro system installed and you are having problems with your system, you should go through the checklists and testing in the chapter, "How to Install Your Synchro® Blended Pulse System".

Shortcut! If all else fails, your Synchro system comes with two "limp home" options. The first is your bypass cable (Part No. 116200-007) that bypasses the electronic flow module completely and routes power directly from the battery to your Synchro nozzle valves. The valves will then lock open and you can spray normally. And if that option fails, you can unscrew each nozzle valve and remove the valve poppet (the little cylinder with the spring attached) and replace the valve or, you can remove the entire nozzle valve and replace the diaphragm check valve you removed when you installed your Synchro system. You can then use manual or automatic pressure control to spray out your tank of material.

Our experience has taught us that almost all problems are caused by **simple wiring failures.** Generally, visual and "hands-on" inspection of all connectors - on the booms and on the modules - will reveal open or short circuits. When looking for boom connections, be sure to operate and cycle any boom folding, lifting and lowering mechanisms since many connection problems are caused by the boom motion. Don't forget to check the connections to your rate controller, GPS system or any other electronics that drive your spray application.

The second most common problem is **blown fuses**. Check all fuses in the Synchro system modules and cables. Also check any vehicle fuses that might be supplying power to your system. Before replacing a fuse, inspect the wiring to find any obvious problem.

FUSES TO CHECK

One 30 amp automotive blade type fuse is located in the main power wire assembly, near the battery connection. This fuse limits the current to the three boom sections of nozzle valves. If this fuse blows, check for a short in the main power wire assembly before replacing fuse.

Three 10 amp, glass type fuses are panel mounted in the side of the flow control module. Each fuse limits the current to one boom section of nozzle valves. If this fuse blows, check for a short in the black wire of the corresponding boom section before replacing fuse.

Six 5 amp, self-resetting thermal fuses are circuit board mounted within the flow control module. Each fuse limits the current to the even, or odd, valves of one boom section. If this fuse blows, check for a short in the white or green wire of the corresponding boom section, or black nozzle valve wires. These fuses are self-resetting and will reset after a cooling time.

One 10 amp automotive blade type fuse is located in the power wire of the cab control box near the battery connection. This fuse limits the current to the cab control box, pressure control module, and ignition circuit of the flow control module. If this fuse blows, check for a short in the cab control wiring, ignition circuit, or circuit to the pressure regulating valve before replacing fuse.

Erratic behavior of your system may be caused by **low battery voltage.** Check the voltage being supplied to your Synchro system *while it and any other electrical accessories are on.* Don't forget that lights and electric motors such as injection pumps, boom actuators, foam markers and pressure regulating valves can draw significant current for brief periods. Your Synchro system needs a minimum of 12 Vdc. Typical vehicle system voltage is 13 - 14 Vdc.

The second most common problem we have seen is **clogged valves.** This is almost always due to one of two things. On new or retrofit installations, Teflon® pipe tape seems to escape past filter screens and lodge in the valves. Or if you did not install proper filters upstream of your nozzle valves, you'll get debris in the valves. A clean system, including a good flushing before you install the nozzle valves, goes a long way in preventing clogged valves.

Here are some specific troubles and suggested fixes. The fixes are in the order of ease to fix and highest likelihood of occurrence.

VALVE TROUBLE

An individual, single valve is not pulsing?

Poor connection. Check wiring connection to valve coil.

Loose coil. Tighten coil nut.

Stuck poppet. Disassemble valve and check for stuck poppet.

Coil failure. Replace coil.

Valve failure. Replace valve.

None of the valves on the sprayer are pulsing?

Pressure may be above maximum limit for valves (usually 100 psi). Reduce pressure.

Low or no voltage to module. Check wiring and fuses. Check battery.

Boom shut-off signals incorrect. Check wiring to module.

Module failure. Replace module.

Application rate out of range for speed, pressure or nozzles. Check.

Every other valve is not pulsing?

Bad valve connector, green or white wire. Check wiring.

Module failure. Exchange main wires to boom sections to see if problem is limited to one boom output connector on the module or one boom section on sprayer. If problem is in module, exchange module. If in boom section, check wiring.

Several valves in a row are not pulsing?

Bad valve connector - likely the black wire. Check, repair or replace.

A valve is dripping after shut off?

Debris in valve. Disassemble and clean.

Damaged valve seat or seal. Replace valve body or poppet.

Broken spring. Replace.

Stuck poppet. Clean, repair or replace.

Missing parts in valve. Replace.

Drips from valves while pulsing?

Spray pressure too low. Adjust pressure.

Target spray rate too low. Increase rate or use smaller spray nozzles.

One valve sprays, but does not pulse?

Poppet is stuck. Clean, repair or replace.

Debris in valve. Disassemble and clean valve.

All valves spray, but none pulse?

Target spray rate is below range for pressure, speed and spray nozzles. Check rate and setting on controller. Adjust pressure upward, increase speed or use larger nozzles.

Short in valve green or white wire. Inspect and repair.

Module failure. Replace.

Valves continue to pulse when sprayer is stopped?

Boom shut-off wiring not correct or wiring faulty. Inspect and correct.

BOOM SECTION TROUBLE

Left, center and right booms do not correspond with shut-off switches on rate controller panel?

Boom output connectors in wrong order. See installation instructions and correct.

Boom shut-off wiring in wrong order. See installation instructions and correct.

One boom section does not work properly?

Bad wiring connection, module failure or faulty boom shut-off connection. Exchange main output wires to boom sections to see if problem is limited to one boom output connector on the module or one boom section on sprayer. If problem is in module, exchange module. If in boom section, check wiring.

All or some master or slave module sections don't work?

Faulty wiring connection. Check boom output and boom shut-off wiring. Also check connections between master and slave modules.

No slave ignition or main power. Check power to module.

Blown fuses on slave module. Check and replace.

SYSTEM RESPONSE AND PRESSURE TROUBLE

System flowrate either goes to full (no pulsing) or lowest (very short pulses) flowrate and does not appear to respond to increase or decrease commands?

Polarity of "servo" input to master flow control module is reversed. Install the adapter or splice wires to reverse polarity.

Synchro system is not receiving proper signals from rate controller. Check rate controller connections. If still inoperative, disconnect "servo" input connector to master flow module and use jumper wires from battery to apply +/-or -/+ signals to module's "servo" input pins. If Synchro system responds, problem is with rate controller. If Synchro does not respond, problem is in module. Check switch settings and jumpers on the module circuit board. If problem persists, replace module and contact your dealer.

Flow control system is unstable - it "hunts" or oscillates when rate is changed?

Rate controller is set for too high sensitivity or too fast actuation of pressure control valve (before Synchro system was installed).

Decrease rate controller sensitivity and speed of change. Contact your Synchro or rate controller dealer.

Synchro flow control module response time set to a too short time. Change DIP switches (Figure 10) on circuit board.

Flow control system is sluggish and slow to settle on target rate?

Rate controller is set for too low sensitivity or too slow actuation of pressure control valve (before Synchro system was installed). Increase rate controller sensitivity and speed of change. Contact your Synchro or rate controller dealer.

Synchro flow control module response time set to a too long time. Change DIP switches (Figure 10) on circuit board.

Pressure control system adjusts pressure to maximum or minimum, never in-between?

Polarity of output wires to pressure regulative valve reversed. Reverse wires to valve to retest.

System response set too fast. Adjust sensitivity and response dials on circuit board. See installation instructions.

Incorrect settings on pressure module circuit board (valve load resistor, valve mode DIP switch, auto/manual jumper, run/hold jumper). Follow instructions in installation instructions and correct as needed.

Failure of pressure sensor. Check voltage on pressure sensor lines while system is at various pressures. See installation instructions for pin-out. Replace pressure sensor if needed.

Pressure control system is unstable - it "hunts" or oscillates when pressure setpoint or sprayer application rate is changed?

Pressure controller is set for too high sensitivity or too fast response time. Decrease controller sensitivity and response time. See installation instructions and discussion of Figure 11.

Pressure control system is sluggish and slow to settle on pressure setpoint?

Rate controller is set for too low sensitivity or too slow response speed. Increase rate controller sensitivity and speed of change. See installation instructions and discussion of Figure 11.

No response to pressure change switch?

Faulty wiring to cab control box or pressure control module. Check all wires and connectors.

No power to module. Check connections and voltage supply to module.

Faulty pressure regulating valve. Disconnect valve and attempt to cycle by connecting jumper from battery to valve input wires. Follow manufacturer's instructions. Repair or replace valve or valve motor if needed.

Incorrect settings on pressure module circuit board (valve load resistor, valve mode DIP switch, auto/manual jumper, run/hold jumper). Follow instructions in installation instructions and correct as needed.

Faulty module. Contact dealer for replacement.

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9. Parts List

116800-001	Owners Manual
116150-001	Flow Control Module, 12VDC
116150-002	Flow Control Module, 24VDC
116149-002	Slave Flow Control Module, 2VDC
116149-001	Slave Flow Control Module, 24 VDC
116130-002	Pressure Control Module, 12 VDC, 2P
116300-002	Cab Control Unit, 2P
116301-001	Pressure Sensor, 100 psi
116400-001	Enclosure Assembly, 2M
116400-002	Enclosure Assembly, 3M
116200-001	Power Cable Assembly.
116200-025	Ignition Cable Assembly.
116200-002	Cab Interconnect Cable Assembly.
116200-003	Slave Interconnect Cable Assembly.
116200-004	Raven Valve Input Adapter
116200-005	Mid-Tech Valve Input Adapter
116200-006	Boom Shutoff Input Adapter
116200-007	Valve Bypass Adapter
116200-013	Nozzle Alternator
116200-014	Boom Extension, 4 ft.
116200-015	Cab Control Synchro Valve Adapter
116200-011	Extension, 2 Conductor, 14 gauge, 10 ft.
116200-010	Extension, 3 Conductor, 14gauge, 10 ft.
116200-008	Extension, 4 Conductor, 14 gauge, 10 ft.
116200-009	Extension, 2x2 Conductor, 14 gauge, 10 ft.
116200-024	Raven Valve Output Adapter
116200-023	Spraying Systems Valve Output Adapter
116200-016	Cab Control Manual Valve Adapter
116200-017	Synchro Valve Adapter
116200-018	Auto. R/H Adapter, Pressure control unit
116200-019	Auto. R/H Adapter, Flow control unit
116500-002	Valve Tool
116200-021	Valve Input Polarity Adapter
116200-022	Valve Output Polarity Adapter
116500-001	Seal Kit
116401-002	Coil Kit, 24 inch
116401-001	Coil Kit, 36 inch
116900-001	Installation Kit
715022-202	O-ring, #117 Viton
715040-176	Tie Wrap, 7" black
716009-002	Valve Body
716009-005	Valve Stem
706500-003	Packard Connector Removal Tool

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10. Capstan Ag Systems Warranty Policy

Capstan Ag Systems, Inc., the Seller, warrants to the original Purchaser/User, its products to be free from defects in material and workmanship in normal use and service for a period of one year from the date of purchase.

Purchaser, by its acceptance of Seller's product, assumes all risk and liability of the consequence of any use or misuse by Purchaser, its employees or others.

The Seller's obligation under this warranty shall be limited to the repairing or replacing, at Seller's option, the product or part thereof which Seller's inspection discloses to be defective, free of charge, FOB point of manufacture, provided that the Buyer (i) Notify Seller of the defect within thirty (30) days of failure; (ii) Returns the defective product to Seller, transportation prepaid; and (iii) Establishes that the product has been properly installed, maintained, and operated in accordance with Seller's instructions or the instructions contained in its operations or maintenance manuals and within the limits of normal usage.

All replacement products, or parts thereof, furnished under this warranty, will be in-voiced in the usual manner and adjustments will be made after the product, or part thereof, claimed to be defective has been returned to and inspected at Seller's factory.

Replacement products, or parts thereof, furnished under this warranty shall be FOB Buyer's location, and Seller shall not be responsible for installation costs (For all international transactions, replacement products shall be furnished FOB Seller's factory and Buyer shall be responsible for all customs and brokerage fees.) Buyer shall be liable for all freight, inspection and handling costs if such product or such parts do not prove to be defective. In no event will any claim for labor or incidental or consequential damages be allowed for removing or replacing a defective product. No warranty is made as to any product or part which has been subject to misuse, abuse, accidents, or alterations, or to improper or negligent use, maintenance, storage, transportation or handling.

The liability of Seller under this warranty, or for any loss or damage to the products whether the claim is based on contract or negligence, shall not in any case exceed the purchase price of the products and upon the expiration of the warranty period all such liability shall terminate. The foregoing shall constitute the exclusive remedy of the Buyer and the exclusive liability of the Seller.

The terms of this warranty do not in any way extend to any product which was not manufactured by Seller or an affiliate of Seller.

This warranty shall be void, and Seller shall not be liable for nay breach of warranty, if the product or parts shall have been repaired or altered by persons other than Seller, unless expressly authorized by Seller in writing.

The foregoing warranty is exclusive and is in lieu of all other warranties expressed or

implied. All implied warranties of merchantability and fitness for a particular purpose are hereby disclaimed by Seller and are excluded from this agreement. Seller shall not be liable for any incidental or consequential damages resulting from any breach of warranty.

Limitation of liability – Buyers exclusive remedy for breach of warranty shall be repair or replacement of defective products: Provided, if the products are incapable of being repaired or replaced, Buyer's exclusive remedy shall be money damages, but such damages shall not exceed the purchase price of the products.

Any claim for breach of Seller's warranty must be in writing addressed to Seller and must set forth the alleged defect in sufficient detail to permit its easy identification by Seller. All breach of warranty claims must be made within thirty (30) days after expiration of the warranty period which is applicable to the defective product. The applicable time periods are set forth in the above warranty term. Any breach of warranty claim not timely made will not be honored by Seller and will be of no force and effect.

On any claim of any kind, including negligence, Seller's liability for any loss or damage arising out of, or from the design, manufacture, sale, delivery, resale, installation, technical direction of installation, inspection, repair, operation of use of any products shall in no case (except as provided in the term entitled Patent Indemnity) exceed the purchase price allocable to the products.

In no event, whether as a result of breach of contract or warranty or alleged negligence, shall Seller be liable for incidental or consequential damages, including, but not limited to: personal injury, loss of profits or revenue, loss of use of the equipment or any associated equipment, cost of capital, cost of substitute equipment, facilities or services, downtime costs, environmental damage, crop losses, or claims of customers of Buyer for such damages.

Patent Indemnity. Seller retains for itself any and all property rights in and to all designs, inventions and improvements pertaining to any products and to all patents, trademarks, copyrights and related industrial property rights arising out of the work done in connection therewith. Buyer expressly agrees that it will not assert any rights to property rights retained herein by Seller.

11. Spray Nozzles, Tips and Equipment Catalogs and Technical Publications

Insert your spray nozzle catalogs and information sheets here.

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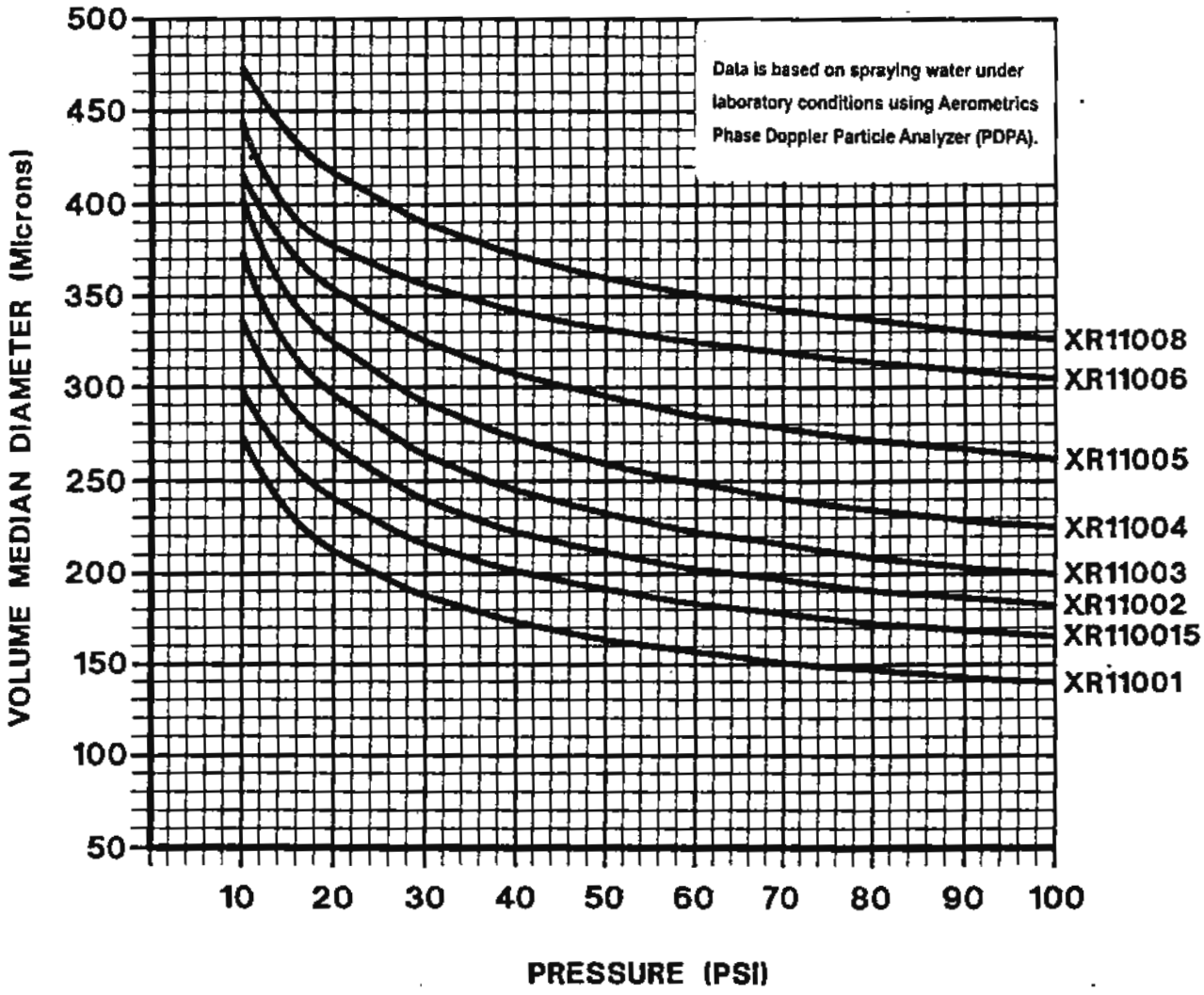
DESCRIPTION

XR TEEJET® EXTENDED RANGE FLAT SPRAY TIPS VOLUME MEDIAN DIAMETER VERSUS PRESSURE CURVES

CAPACITIES XR11001 THRU XR11008 SPRAYING WATER AT 70° F

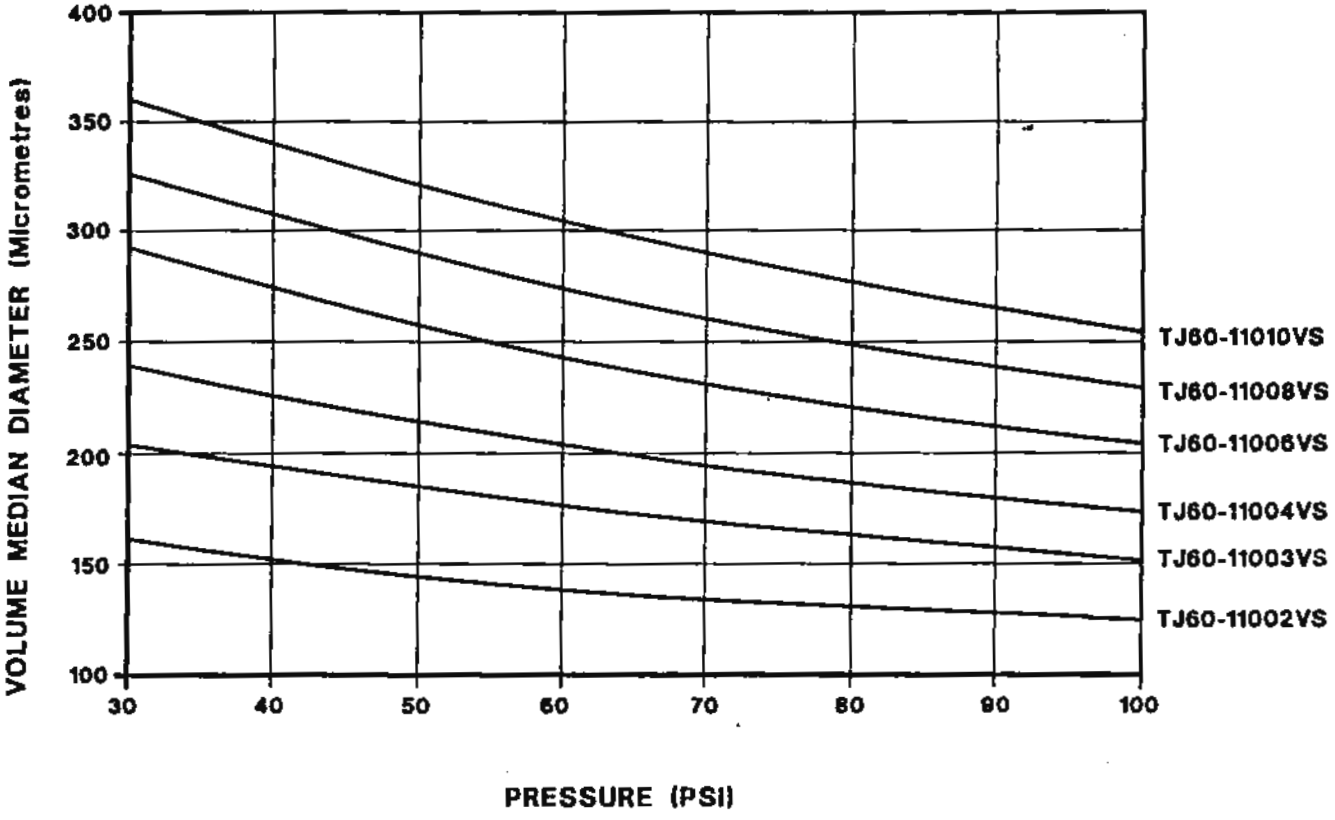


NOTE: THE ABOVE DATA APPLIES ONLY TO THE XR TEEJET® EXTENDED RANGE FLAT SPRAY TIPS WITH THE MATERIAL CODES "VS" (STAINLESS STEEL WITH VISIFLO® COLOR-CODING) AND "VP" (POLYMER WITH VISIFLO® COLOR-CODING).

Spraying Systems Co.
North Avenue at Schmale Rd. • P.O. Box 7900
Wheaton, IL 60189-7900

Date	Data Sheet No.
Jan. 11, 1993	11825-44

TJ60-110 SERIES TWINJET® FLAT SPRAY TIPS
CAPACITIES 11002VS THRU 11010VS



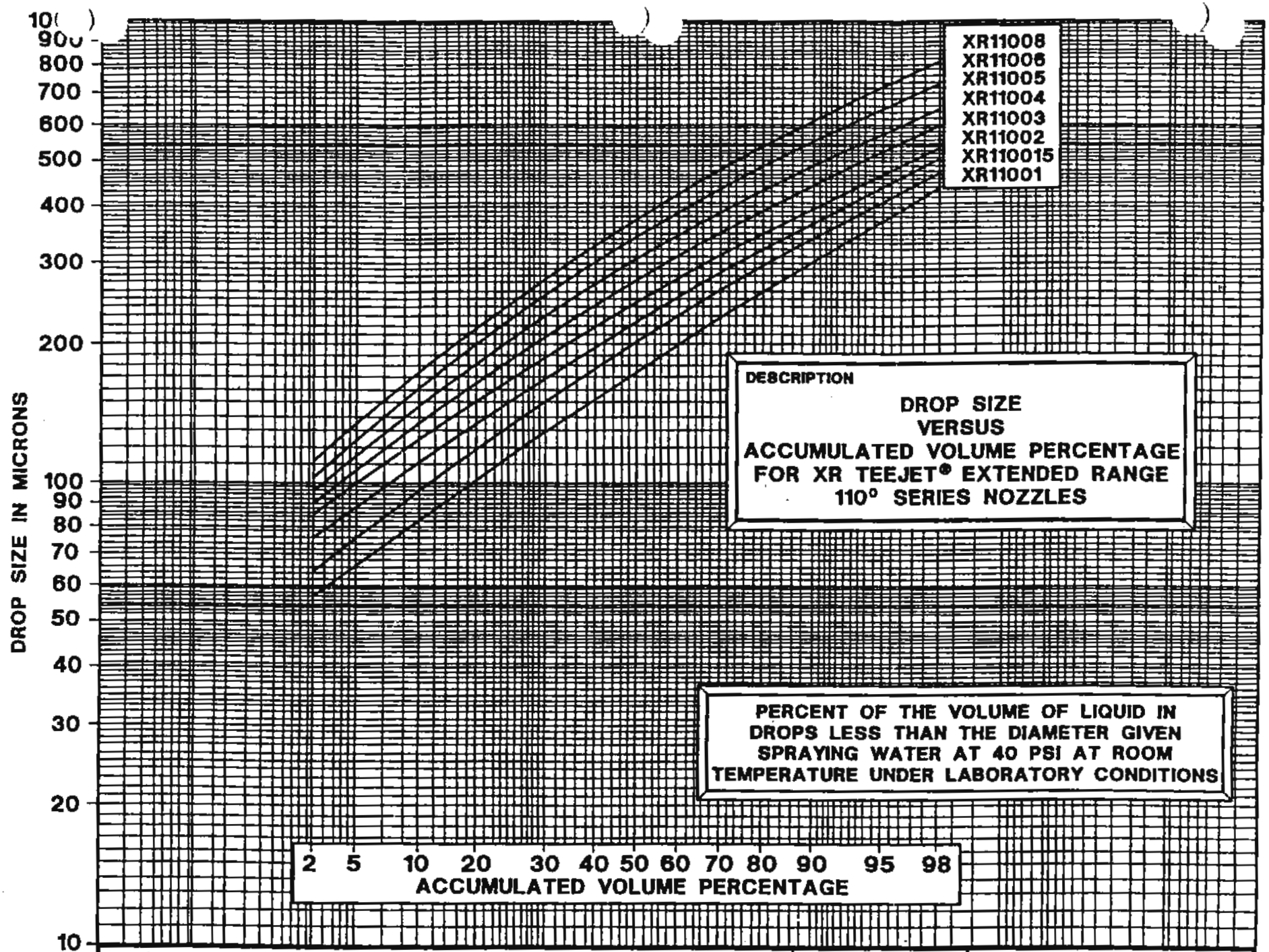
DESCRIPTION

VOLUME MEDIAN DIAMETER (VMD) VERSUS PRESSURE SPRAYING WATER AT 70° F.

Data is based on spraying water under laboratory conditions using the Aerometrics Phase Doppler Particle Analyzer (PDPA). All values are computed utilizing the procedures for determining spray characteristics as outlined by ASTM (Standard E799)

Spraying Systems Co.
Spray Nozzles and Accessories
North Avenue at Schmale Rd. • P.O. Box 7900
Wheaton, Il. 60189-7900

Ref:	Data Sheet No.
Revision No.	11825-67



Spraying Systems Co.
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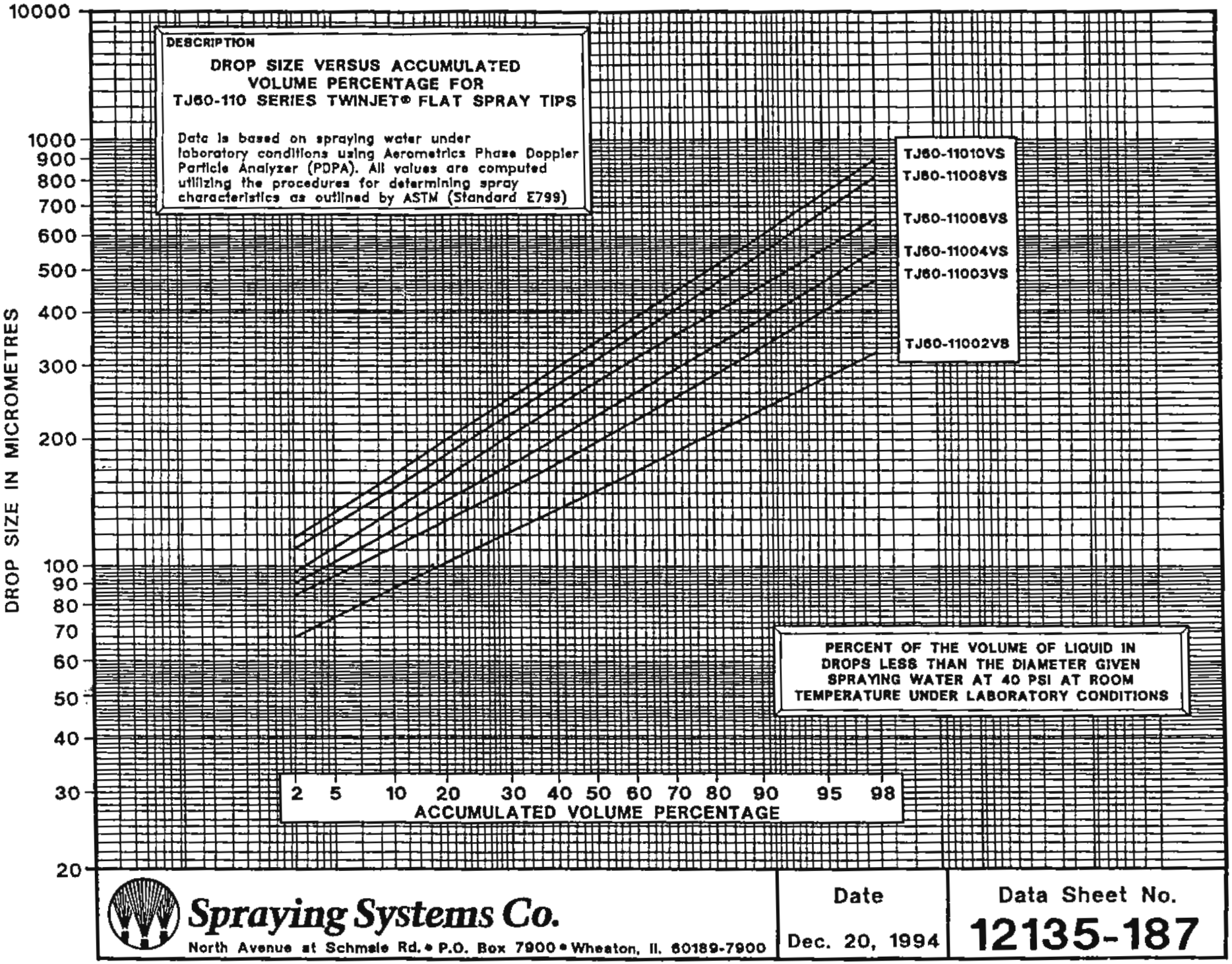
Date	Data Sheet No.
July 10, 1992	12135-70



Spraying Systems Co.

North Avenue at Schmale Rd. • P.O. Box 7900 • Wheaton, Il. 60189-7900

Date	Data Sheet No.
Dec. 20, 1994	12135-187

12. Technical Aspects of the Synchro® Blended Pulse Spray Control Concept

Contact your Synchro dealer for the latest technical information sheets.

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13. Special Technical Application Notes

Contact your Synchro dealer for the latest special application notes.