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# **Arrow AutoCAT™2 Series**

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## **Intra-Aortic Balloon Pump (IABP) System**

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### **Service Manual**

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### CHAPTER 1: Clinical Uses

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Intra-Aortic Balloon Pumping (IABP), or counterpulsation, is a widely accepted therapeutic method of temporarily supporting patients with impaired left ventricular function. Impaired left ventricular function causes low cardiac output and inadequate coronary perfusion. Counterpulsation helps to balance the myocardial oxygen supply and demand in these patients. The hemodynamic effects of counterpulsation are immediate, predictable, and most importantly, decrease morbidity and mortality. The IABP can be initiated rapidly. For this reason, the IABP has become an important therapeutic tool in a variety of clinical settings, including Emergency Departments, Cardiac Catheterization Labs, Operating Rooms, and Intensive Care Units.

This chapter provides an overview to the clinical uses of the IABP System. The details of how the AutoCAT™2 Series works are described in Chapter 3, Principles of Operation.

The contents of this chapter include:

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## Physiological Basis of IABP

The overall goal of IABP is to provide cardiac support to patients whose myocardial oxygen supply and demand are imbalanced. Counterpulsation achieves this goal by increasing coronary and systemic perfusion, decreasing afterload (myocardial work) and decreasing preload.

The IABP exerts its effect by rapidly shuttling helium gas in and out of the balloon chamber. At a precisely timed interval, the gas enters the balloon chamber within the aorta. As the gas is shuttled into the balloon, it occupies a space within the aorta equal to its volume. The usual adult balloon volume is 40cc although alternate sizes (30 and 50cc) may be better tolerated clinically. The sudden occupation of space by the gas upon inflation causes blood to be moved from its original position. The blood is moved superiorly and inferiorly to the balloon. Along with the movement of blood is a sharp increase in the pressure in the aorta. Since the volume in the aorta is suddenly increased and the aortic wall is fairly rigid, the intra-aortic pressure increases sharply.

With deflation of the IAB, the sequence of its effects is reversed. A sudden 40cc fall in aortic volume causes a sudden decrease in aortic pressure within that localized area. In response to the fall in pressure, the blood in adjacent areas moves to equalize the pressure within the aortic cavity as a whole. The evacuation of 40cc of volume from the aorta is timed to occur precisely, prior to or with ventricular ejection (systole).

Displacement of blood volume (both away from the balloon on inflation and toward the balloon on deflation) is the mechanism by which the IABP alters the patient's hemodynamic state. To alter the hemodynamic state for the greatest benefit, the IABP must be set so that inflation and deflation of the balloon occur at the optimal times.

To provide maximum benefit to the patient, the IABP must have a reliable trigger so that the assist occurs consistently in each cardiac cycle. ECG triggering utilizing the R-wave or the QRS complex is usually the simplest way to accomplish this, and is the preferred mode used by the IABP. In addition, inflation and deflation points must be timed very precisely. Optimum timing results in increased Augmentation (AUG) and decreased Diastolic Pressure (DIA). [If the balloon is inflated too early, Stroke Volume (SV) and Cardiac Output (CO) may be reduced. Late inflation will result in smaller increases in AUG and perfusion. If the balloon is deflated too early, DIA (and thus workload) is not decreased. Late deflation may increase the ADIA (thus workload), causing a further imbalance in myocardial oxygen supply and demand.] In AutoPilot™ mode, timing is automatically optimized by the AutoCAT™2 series and automatically adjusts for variations in heart rate and for arrhythmia's. Operator mode allows timing to be set by the user and then adjusts for most variations in heart rate and rhythm.

Extensive clinical experience shows that Intra-Aortic Balloon Pumping is a safe and effective method of providing cardiac assist to appropriate patients<sup>20</sup>. By increasing coronary and systemic perfusion and decreasing preload and afterload, the IABP can stabilize critically ill cardiac patients. It is important to initiate IABP as quickly as possible to help minimize further damage to the myocardium. Medical and surgical indications for IABP are described in the following section.

## **1. Clinical Uses**

### **1.1: Clinical Uses of IABP**

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#### **Medical Indications**

##### ***Cardiogenic Shock*<sup>2,6,9,10,13,14,17,27,28,29</sup>**

Cardiogenic shock is a physiological derangement of circulatory failure due to severe depression of myocardial function. Cardiac Output (CO) is markedly depressed and the compensatory mechanisms that usually maintain CO (e.g., increased Heart Rate [HR], increased preload and increased contractility) are no longer sufficient to return systemic perfusion to a life supporting level. CO is further compromised by the loss of contributing myocardium to the contractile process. During cardiogenic shock, further deterioration occurs as a result of dysfunctional compensatory mechanisms, resulting in a vicious cycle that increases the stress on an already over stressed myocardium. Cardiogenic shock may result from several conditions, the most common is following Myocardial Infarction (MI).

Hemodynamic variables are manipulated with pharmacologic agents to break the cycle of cardiogenic shock. It is generally accepted that pharmacologic agents should be used as a first line of therapy. Drug intervention, however, cannot cause increased perfusion to the coronary artery system. In an ischemic state, the coronary arteries are already maximally dilated and are totally dependent on the perfusion gradient. The ability to autoregulate coronary flow is lost.

IABP can help to increase coronary perfusion. The reduction in afterload and the increase in systemic perfusion pressure are also advantageous. Most practitioners agree that early use of IABP increases the probability of survival. IABP should be considered if first line medical therapies do not improve the patient's clinical status within two to three hours. Further losses of viable myocardium can occur if inadequate perfusion is allowed to continue.

The AutoCAT™2 Series should only be used under supervision of qualified medical personnel. Although the AutoCAT™2 Series IABP has an alarm for MAP or AUG, it is highly recommended for an external monitor to be used with the IABP. The external monitor must have alarms for high and low heart rate and blood pressure enabled.

##### ***Pre-shock Syndrome*<sup>2,13</sup>**

Pre-shock syndrome is a condition of deteriorating cardiac function secondary to myocardial ischemia, infarction or mechanical defects. The hallmark signs are decreasing CO, increasing afterload resulting from initial compensatory mechanisms, increasing preload caused by failing cardiac function and the initial signs of generalized systemic myocardial ischemia.

IABP therapy is indicated if first line therapies do not reverse the condition and the patient is still salvageable. Myocardial cells are at risk for irreversible damage. Time is critical because the IABP may prevent further deterioration and provide time for the myocardium to heal before infarction occurs.

***Threatening Extension of MI<sup>16,17,18,23</sup>***

If signs of myocardial ischemia continue after an infarction, a portion of the myocardium is in jeopardy. IABP may salvage viable myocardium in these patients. The IABP can be used to alleviate the hemodynamic instability caused by myocardial ischemia while the physician evaluates further intervention options (e.g., coronary bypass surgery). Early intervention is important.

***Unstable Angina<sup>18</sup>***

Angina is a sign that oxygen supply to the heart is inadequate. Angina sometimes becomes resistant to usual modes of therapy, and the pain continues. Patients with intractable angina often find dramatic relief within 15 minutes of instituting IABP support. This allows time for further evaluation of patient symptoms.

***Intractable Ventricular Dysrhythmias***

Ventricular irritability may result from islands of ischemic myocardium. Cell membranes of the hypoxic cells become unstable and discharge electrical currents in a disorganized manner. IABP can relieve the hypoxic environment of the irritable cells by increasing coronary artery perfusion. Reduced myocardial oxygen demand may also help patients with these dysrhythmias.

***Septic Shock Syndrome<sup>21</sup>***

Septic shock is a state of vascular collapse due to a fall in systemic blood pressure. Bacterial endotoxins paralyze the pre-capillary sphincters, causing a fall in blood pressure. These pre-capillary sphincters are paralyzed in the open position and are unable to maintain a driving pressure for tissue perfusion. At the onset of septic shock syndrome, CO is very high (maintained by elevated Stroke Volume [SV] and HR) and Systemic Vascular Resistance (SVR) is very low. Late in the course of septic shock, profound vasoconstriction increases SVR and decreases CO. Also, it is thought that circulating myocardial depressant factors begin to impair myocardial contractility in the later stages of this syndrome. CO falls, and the patient's condition deteriorates rapidly. In addition, the tissues become unable to utilize the oxygen that is delivered, and increased arteriovenous shunting of oxygen occurs.

The IABP has been employed in some cases of septic shock, generally when the patient is known to have compromised myocardial function. In the early stages of the syndrome, when coronary perfusion is low due to arterial vasodilatation, the IABP may help to increase Coronary Perfusion Pressure (CPP) and supply the heart with extra oxygen. In the late stages, IABP may benefit the patient by reducing afterload when vasoconstriction becomes prominent.

## **1. Clinical Uses**

### **1.1: Clinical Uses of IABP**

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#### ***Cardiac Contusion<sup>26</sup>***

Contusion with subsequent infarction of the myocardium can occur with trauma to the chest wall. The majority of cases of myocardial contusion result from automobile accidents and other blunt chest trauma. Aneurysms involving the contused area can occur.

The necrosis of contused cardiac tissue is very similar to infarction from Coronary Artery Disease (CAD). The acute phase of contusion is characterized by hemodynamic instability, and cardiogenic shock is not uncommon in severe cases. These patients benefit from IABP in much the same way that patients with cardiogenic shock caused by a coronary event benefit from IABP. However, many patients with cardiac contusion are young and without coronary disease. The infarction involves a discrete area and is much less diffuse than infarction caused by coronary obstruction. The long-term prognosis is far better in patients with necrosis caused by contusion if they survive the acute phase. IABP is indicated if conservative measures do not restore hemodynamic stability.

#### ***Prophylactic Support During Diagnostic Interventional and Non-surgical Procedures<sup>3,8,12</sup>***

Patients undergoing ischemic events are sometimes candidates for cardiac catheterization, coronary angioplasty, stents, thrombolytic therapy or coronary atherectomy. Cardiac catheterization is necessary to identify the obstructed arteries that may be successfully treated by coronary bypass surgery. In hemodynamically unstable patients, the catheterization procedure can be hazardous because coronary artery supply is temporarily interrupted during injection of the radio opaque dyes. This interruption of the already inadequate oxygen supply can precipitate sudden deterioration of myocardial functions. Use of IABP increases the probability that angiographic studies can be completed in a controlled manner.

Coronary angioplasty may be contraindicated in a hemodynamically unstable patient with an otherwise correctable lesion. Inflation of the angioplasty balloon temporarily obstructs coronary blood flow. The use of IABP may help to stabilize the patient's hemodynamic condition and increase coronary reperfusion by increasing CPP.

In addition, studies have shown that IABP use after emergency or high risk primary PTCA for acute MI reduces reocclusion and may add strength to reperfusion and improvement of LV function<sup>10,14,15,22</sup>.

Coronary atherectomy may be indicated in specific types of coronary lesions. IABP may support this interventional procedure<sup>24</sup>.

## Mechanical Defects

Mechanical defects that impede forward CO are another group of medical indications for IABP. These defects include valvular stenosis, valvular insufficiency and ventricular septal defect.

### *Valvular Stenosis*

The two types of valvular stenosis are aortic stenosis and mitral stenosis. In **aortic stenosis**, a narrowed valve opening obstructs left ventricular ejection. The left ventricle must generate a higher pressure for a longer period of time to achieve ejection. The left ventricle hypertrophies in response to chronic systolic pressure overload. The pressure during systole greatly increases wall pressure, but this is offset somewhat by the increased wall thickness. The heart functions at its limits of oxygen supply. Indeed, angina is a hallmark of aortic stenosis. Concurrently, CO becomes “fixed” due to the restricted valve orifice. Patients with symptomatic aortic stenosis are in danger of sudden death, presumably due to an ischemic dysrhythmias. The IABP can be used to maximize coronary artery pressure until surgery can be performed. The value of afterload reduction is limited because orifice size, not aortic pressure, prevents left ventricular ejection.

**Mitral stenosis** causes diastolic ventricular underloading. The mitral valve orifice becomes small and restricts the diastolic filling of the left ventricle. As the valve narrows, blood collects in the left atrium and pulmonary circuit. The ventricle becomes dependent on a high left atrial pressure to facilitate left ventricular filling. CO becomes “fixed” because the amount of blood the left ventricle can empty is restricted by the amount it receives. The high pressures and the blood dammed against the stenotic mitral valve cause respiratory insufficiency. Patients often present with pulmonary hypertension and pulmonary edema. Arrhythmias, which can limit coronary filling and jeopardize the myocardium, are associated with a decompensated state of mitral stenosis. The goal of IABP therapy in mitral stenosis is to maximize coronary artery perfusion while further treatment decisions are being made. Afterload reduction has little value because the heart is incapable of increasing its CO. However, afterload reduction may be desirable following valve replacement if left ventricular failure occurs.

### *Mitral Valvuloplasty*

In the event that Mitral Valvuloplasty is chosen as a therapeutic intervention, the IABP may be used to maximize coronary artery perfusion and reduce afterload immediately before and/or after the procedure. The IABP mechanisms of action are the same as those described for mitral stenosis.

## **1. Clinical Uses**

### **1.1: Clinical Uses of IABP**

---

#### ***Mitral Valve Insufficiency***

The two types of valvular insufficiency are aortic insufficiency (see Section 1.2) and mitral insufficiency. In **mitral insufficiency**, the leaflets of the valve become unable to seal off the left atrium from the left ventricle during systole. As a result, a portion of the left ventricle's contents is ejected backward into the left atrium. The left ventricle works under a condition of chronic volume overload and ejects its contents into a relatively low-resistance left atrium. In spite of severe myocardial dysfunction, the heart is able to maintain CO because of the low impedance to ejection. Most of the energy expended is used in fiber shortening instead of tension development. Therefore, the Isovolumetric Contraction (IVC) phase is shortened and myocardial oxygen demand is reduced.

Mitral insufficiency causes fatigue and chronic pulmonary vascular congestion. The left atrium becomes dilated and the left ventricle hypertrophies. If mitral insufficiency is sudden, the heart cannot compensate completely and the patient presents with florid pulmonary edema and cardiogenic shock. It is important to reduce afterload because decreased aortic pressure enhances forward CO and minimizes regurgitation into the left atrium. The IABP may be necessary if pharmacologic agents do not reduce afterload adequately. Reduction of afterload by IABP may be the key to survival following valve replacement. When the incompetent valve is replaced, the left ventricle is forced to eject its full SV into the high pressure aorta. Myocardial workload increases dramatically with the increase in the IVC phase. If the myocardium is dysfunctional (which may not be apparent preoperatively), mortality will be high if myocardial workload is not reduced adequately.

#### ***Ventricular Septal Defect (VSD)***

In VSD, blood is shunted from the left ventricle to the right ventricle with each ventricular contraction (The pressure on the left side of the heart is greater than that on the right.). As blood is shunted to the right side, the SV ejected into the aorta is decreased and right ventricular pressures rise. Blood begins to pool in the systemic venous circuit because the right ventricle is unable to contain the extra volume it receives from the left ventricle.

Systemic venous congestion is the main symptom of VSD. The patient may not show signs of congestive heart failure until the end stages of the disease because there is no obstruction from the pulmonary artery to systemic circulation. IABP increases SV by providing a favorable pressure gradient (with balloon deflation). The left ventricle empties more completely at a lower aortic pressure because less blood is shunted across the septum into the right ventricle. The right ventricle, in turn, is able to empty more completely because the end-diastolic volume is less, relieving wall tension. Right ventricular function is improved and the symptoms of venous congestion lessen.

## Surgical Indications

### ***Prophylactic Preparation for Cardiac Surgery<sup>5,8,19,20,28</sup>***

Induction of anesthesia can be stressful to the cardiovascular system. Several drugs can increase myocardial oxygen demand by increasing HR, SVR or contractility. The stress of surgery can cause similar reactions. It may be appropriate to use IABP in patients with limited myocardial reserves, including patients with:

- unstable angina
- triple vessel disease (all major coronary arteries obstructed)
- left main disease (proven to carry higher mortality and morbidity rates)
- recent MI (within six weeks)
- impending MI
- poor LV function (EF <25%)<sup>4</sup>

The IABP can also be used in conjunction with investigational devices (i.e., LVAD, RVAD, CPS, etc.), if the indication for use of the device is among those listed above as currently approved indications for IABP therapy (e.g., cardiogenic shock, VSD, MI, unstable angina, etc.)

Any hemodynamically unstable patient may benefit from IABP, whether undergoing cardiac or non-cardiac surgery<sup>5,8</sup>. The main objectives are to maintain a margin of safety in myocardial oxygen balance in the pre-bypass or anesthesia induction period and to support the heart in the event of dysfunction in the early postoperative period.

### ***Post-surgical Myocardial Dysfunction<sup>20</sup>***

Post-surgical myocardial dysfunction is popularly known as “post-pump syndrome” or “low cardiac output syndrome”. The etiology is not fully known. The low CO following surgery reflects a global depression of myocardial function. Some proposed etiologies include depression caused by drugs, alterations in perfusion from the cardiopulmonary bypass and intraoperative hypotensive occurrences. The syndrome disappears and cardiac function returns in 24 to 36 hours when appropriate therapies are given. Prognosis is generally very good if baseline cardiac function is near normal and intraoperative infarction is absent.

### ***Cardiac Support Following Correction of Anatomical Defects***

Patients undergoing correction of a VSD or mitral valve replacement for mitral insufficiency frequently need cardiac support following surgery. After repair of these defects, the myocardium must overcome a higher afterload in order to eject the SV. IABP support may be more long term if it takes time for myocardial function to return to normal.

## **1. Clinical Uses**

### **1.1: Clinical Uses of IABP**

---

#### ***Maintenance of Graft Patency Post Coronary Bypass Surgery***

IABP may not be needed to maintain graft patency after coronary bypass surgery.

IABP may be appropriate if cardiac function is compromised and graft patency is jeopardized.

#### ***Pulsatile Flow During Cardiopulmonary Bypass***

This is not an indication in and of itself. The value of pulsatile flow is debatable and has not been resolved. Some cardiopulmonary bypass machines are capable of providing pulsatile flow or can be adapted to deliver pulsatile flow. In most cases, there must be an additional reason to warrant the use of IABP.

#### ***Bridge to Left Ventricular Assist***

Patients who exhibit significant hemodynamic compromise despite IABP therapy, may require more intensive Left Ventricular Support. The IABP may be used until other such devices can be implemented.

## Contraindications

Intra-Aortic Balloon Pumping (IABP) requires an adequate location in which to place the balloon and a functional aortic valve. Further, the clinician must have confidence that the patient will benefit from the procedure. The conditions described below are contraindications.

### Absolute

#### *Hemodynamically Significant Aortic Valve Insufficiency*

If an aortic valve is incompetent, inflation of an IAB will result in increased regurgitation into the left ventricle. The flow of blood back into the left ventricle will reduce forward CO, further aggravating the patient's abnormal hemodynamics.

#### *Aortic Aneurysm or Aortic Wall Disease*

Movement of an IAB may jeopardize the integrity of the aortic wall in a patient with either of these conditions. Rupture of the aortic wall must be avoided.

### Relative

#### *Atherosclerosis*

In some patients with severe atherosclerosis, the femoral arteries may be sufficiently plaque-filled and tortuous to prevent placement of the balloon.

#### *End-stage Disease*

Use of IABP may not be justified in some patients with late-stage terminal illness. This is an aggressive and invasive procedure and should be used only if the patient will derive significant clinical benefit.

## **1. Clinical Uses**

### **1.2: Contraindications and Potential Complications of IABP**

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#### **Potential Complications**

As with any invasive procedure, there are risks associated with IABP use. Potential complications arising from the use of IABP include the following:

*Limb ischemia* may result from obstruction caused by the presence or improper position of the catheter.

*Aortic wall damage* may be caused by stripping of the endothelial surface, improper placement of the catheter or unsuspected aortic wall disease.

*Thrombosis* can occur around the insertion site, on the aortic intima or on the catheter, if it is left dormant in the aorta.

*Embolus formation* may occur from the beginning of insertion to the post-removal phase. Materials known to embolize include thrombi, plaque, gas and air.

*Infection* may result when a debilitated patient is exposed to nosocomial organisms in the critical care setting.

*Thrombocytopenia* may be caused by the presence of the balloon, especially if the balloon totally occludes the aorta during inflation.

*IAB Rupture and/or Entrapment* If calcified plaque is present in the aorta around the area of the IAB, repeated contact with plaque may cause a loss of IAB membrane integrity. This may result in blood in the catheter or in prolonged exposure, clot in the IAB membrane. This may make IAB removal difficult. If blood is present or a leak is suspected, extreme caution must be exercised during IAB removal. Surgical removal should be considered.

*Bleeding* may occur at the IAB insertion site. If anticoagulation is given (increased ACT or aPTT), a higher risk of bleeding complications may be noted.





### CHAPTER 2: Installation Procedures

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After the AutoCAT™2 Series IABP System is delivered to your hospital or purchasing facility, an Arrow International Field Engineer or representative will prepare the AutoCAT™2 Series for operation and thoroughly check its operational readiness. You must ensure that you have fulfilled certain pre-installation requirements.

This chapter outlines your pre-installation responsibilities and the installation procedures to be performed by Arrow International.

The contents of this chapter include:

<b>2.1: <i>Installation Procedures</i></b> . . . . .	<b>2-3</b>
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Circuit Breaker . . . . .	2-5
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### Pre-installation Requirements

As the user of the AutoCAT™2 Series IABP System, it is your responsibility to ensure that the following pre-installation requirements have been fulfilled prior to the system installation:

1. Make sure that the AC power source available to the installation site is properly grounded. The AutoCAT™2 Series will operate on 90-264 volt and 50/60 Hz.

#### **WARNING – ELECTRIC SHOCK HAZARD**

An electric shock hazard may exist with this system. Always operate the AutoCAT™2 Series from a 3-wire hospital-grade AC electrical system with a separate ground. Do not remove the round grounding pin from the system's plug. Do not use a 3-wire to 2-wire adapter to avoid the system's ground. Do not place fluids in the storage compartments on top of the AutoCAT™2 Series.

#### **WARNING**

The biomedical engineering department or other qualified person should verify the integrity of the AC power system ground. In addition, the ground should be checked periodically.

*If you are not certain that your power source is active and properly grounded, call the biomedical engineering department, hospital electrician or other qualified personnel.*

2. ECG patient electrodes, pressure transducers or transducer adapter cables are not supplied with the AutoCAT™2 Series IABP System. Make sure that they are available at the installation site.
3. Confirm that replacement supplies of USP helium and recording chart paper are available. (See Section 6.2 for ordering information.)

#### **WARNING**

The AutoCAT™2 Series IABP System requires a trained operator who has read and understands all sections of this manual prior to using the AutoCAT™2 Series IABP System. Only medical personnel trained in the use of IABP devices and acting under a physician's orders should operate this system.

4. The AutoCAT™2 Series should be operated by educated personnel only. Make sure that you have allocated adequate education time for potential users.

Arrow International, Inc. clinical specialists are willing to provide your staff with Basic or Advanced Education, according to your institution's requirements. Arrow provides a 24-hour Support Line for questions regarding AutoCAT™2 Series and other Arrow IABP operational and troubleshooting issues and may be accessed by calling:

**1-800-447-IABP (4227) (U.S.A. & Canada)  
or 1-617-389-8628 (outside the U.S.A. & Canada)**

General product information may be requested from your local sales representative or distributor, or by calling:

**1-800-523-8446 (U.S.A. & Canada)  
or 1-610-378-0131 (outside the U.S.A. & Canada)**

## 2.1. Installation Procedures

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### Service Installation

To insure that your AutoCAT™2 Series IABP System is properly installed and operational, an Arrow International representative will:

1. Open the packaging boxes/crates and verify its contents.

You should receive the AutoCAT™2 Series console and an accessory kit containing:

- One box of recorder paper
- Two Helium washers
- One Helium tank adapter for disposable He tanks
- One of each of the following accessories:
  - One ECG 5 lead cable (IAA-09837 or IAA-09837E)
  - One Phone to Phone cable (May be standard 1/4 inch Phone plug, 4.4 mm Bantam plug or 3.5 mm Micro phone plug)
  - Alternative cables are available for different monitoring systems. Consult your sales, clinical or field service representative or the product reference guide for available cables.
- One case of disposable HE (4 per case)
  - OR-
  - One refillable He canister
- One Dual Hanger IV pole
  - OR-
  - One Console bracket mount for remote mounting of display/control head.
- One operation manual
- One Power cord (North American, European, Australian, or United Kingdom)
- One AutoCAT™2 Series Pak

You should also receive any optional accessories that you ordered with the AutoCAT™2 Series.

2. Confirm that the AutoCAT™2 Series is free from shipping damage.
3. Install a new 500 psi disposable canister of USP helium (or 2000 psi refillable/disposable tank). The helium tank is located behind left rear door on the main unit.

NOTE: The helium connection accepts a standard helium tank yoke assembly. A special adapter is provided if the 500 psi disposable tank is to be used. Place the adapter into the helium regulator assembly and tighten. The 500 psi disposable tank may now be installed. A helium washer *must be installed* between the adapter and the yoke for a leakproof seal. Open the valve on the He adapter by turning in the “open” direction. This will begin the flow of helium from the tank to the AutoCAT™2 Series.

4. Switch on the DC circuit breaker.

### **WARNING**

Use only Accessories supplied with the AutoCAT™2 Series pumps or meet specifications provided by Arrow International. Use of other accessories may not result in correct system operation.

The DC circuit breaker was switched off at the factory to prevent damage to the AutoCAT™2 Series during shipping. The DC circuit breaker is located in the upper right of helium storage compartment.

5. Attach umbilical cord to AutoCAT™2 Series display head. The umbilical cord is stored in the Helium compartment during shipping.
6. Switch ON the AutoCAT™2 Series and check to make sure that the system's displays, indicators, controls, alarms, strip chart recorder, built-in battery and pneumatic drive module function properly.

### **AC Power**

The AutoCAT™2 Series is equipped with a power entry module located at the bottom center of the I/O panel. The power entry module utilizes an IEC 320 inlet which features a detachable power cord, a power cord retaining clamp and a fuse drawer with two AC fuses which fuses both sides of the AC power line. Both fuses are required for normal operation. The AutoCAT™2 Series is shipped with the AC fuses already installed.

The power cord can be removed from the power entry module by unlatching the cord retaining clamp and pulling the cord out. This action disconnects the pump from main power. The power cord can be installed into the power entry module by inserting power cord connector firmly into the inlet and securing the cord by snapping the cord retaining clamp over the cord.

Just below the Main Power Switch, there are two lights. A green light labeled POWER INDICATOR, when lit, indicates that the AC power cord of the AutoCAT™2 Series is plugged into an active AC power source. A yellow light labeled BATTERY CHARGED, when lit, indicates the battery is at least 80% charged, when connected to AC power.

The AutoCAT™2 Series is also equipped with an equipotentiality connector located on the lower right side of the front panel of the AutoCAT™2 Series.

### **Circuit Breaker**

The circuit breaker must be switched on for the pump to operate in the Battery mode and for the Battery to charge. Verify that it is switched ON prior to the pump being placed in use.

An alert message will appear on the LCD display if the Circuit breaker is switched OFF. If the power is lost when AC power is discontinued, check the circuit breaker and make sure it is in the ON position.

### **Time Meter**

The time meter is located in the lower left hand corner of the helium storage compartment. This storage compartment is located on the left rear of the main console. The power switch of the AutoCAT™2 Series must be switched ON in order for the time meter to display the total running time (in hours) of the AutoCAT™2 Series.

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#### CHAPTER 3: Principles of Operation

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Chapter 1 outlined the AutoCAT™2 Series and IABP indications. This chapter describes the functions of the AutoCAT™2 Series in more detail. Understanding the fundamentals of how the AutoCAT™2 Series works will enable you to operate and maintain the AutoCAT™2 Series efficiently. It is important that you read this chapter before attempting the operating, calibration, maintenance and troubleshooting procedures.

The first section in this chapter describes the configuration of the AutoCAT™2 Series. The Second section described the Operation of the AutoCAT™2 in the AutoPilot™ mode and the Operator mode. The next two sections outline the mechanics of how the AutoCAT™2 Series works: the input and output connections that provide the signals necessary for operation (Section 3.2), and the function keys that allow you to select the operating parameters to optimize patient IABP support (Section 3.3).

The contents of this chapter include:

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### **3. Principles of Operation**

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## **Introduction**

The AutoCAT™2 Series has two models, the AutoCAT™2 and the AutoCAT™2 WAVE. Each model performs the same operations and functions with one exception. The AutoCAT™2 WAVE can accept a LightWAVE™ Fiber Optic Arterial pressure sensor from Arrow IAB catheters with this feature. The LightWAVE™ sensor provides a high fidelity, virtually real time AP signal which allows a unique physiologic timing algorithm to be available. The WAVE™ algorithm monitors the ECG and AP waveforms or AP waveform only to determine the optimal inflation timing setting in real time. This timing algorithm monitors the patient's AP signal on a beat to beat basis and adjusts inflation timing for that specific beat.

When the LightWAVE™ signal is available, it is selected and the WAVE™ timing algorithm is used automatically.

All other functions of the pump are the same. Functions specific to the AutoCAT™2 WAVE will be noted throughout the remainder of the manual.

## **Overview of the AutoCAT™2 Series**

The AutoCAT™2 Series IABP System utilizes advanced computer technology to select and maintain precise IAB inflation and deflation timing and triggering based on current physiological data from the patient. The system offers two modes of operation, the AutoPilot™ mode, where most functions are automatically selected and controlled by the IABP and the Operator mode where the user has control over most settings and selections.

The system consists of two components: the pump control/display module and the pneumatic drive module with attached wheels for easy transport. A twelve foot (3.6m) communication cable connects the pump control module to the pneumatic drive module (an optional fifteen foot (4.6m) communication cable is also available). The exterior of the AutoCAT™2 Series is constructed of structural foam for reduced weight and high durability during transport. To allow you to maximize the amount of working space during operation (especially during transport), the pump control/display module can be removed for optimum convenience.

## **Function of the AutoCAT™2 Series**

The AutoCAT™2 Series IABP is an advanced microprocessor based system designed for in hospital and transport applications. The AutoCAT™2 Series is compact, lightweight and can run with full operational capability for a minimum of 90/180 minutes on battery power.

The AutoCAT™2 Series has two modes of operation, the AutoPilot™ mode and the Operator mode. The AutoPilot™ mode selects and changes signal sources, trigger modes and timing settings to maintain optimal counterpulsation with minimal user intervention. In the Operator mode, the clinician can select and set most IABP functions. The AutoCAT™2 Series can interface with most bedside monitors and accepts inputs from patient cables and transducers. The AutoCAT™2 WAVE can accept input from a high fidelity AP source the LightWAVE™ sensor from Arrow IAB catheters with this option.

### **3. Principles of Operation**

#### **3.1: Overview of the AutoCAT™2 Series**

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The system is designed to save time while maintaining optimal counterpulsation for the patient by automating many of the IABP functions.

In the AutoPilot™ mode, the AutoCAT™2 Series automatically:

- Selects and changes ECG and AP sources
- Selects and changes the trigger mode
- Selects the timing method
- Sets and adjusts timing automatically

In both AutoPilot™ and Operator mode the AutoCAT™2 Series automatically:

- Purges the pneumatic system for rapid start up of counterpulsation
- Optimizes He concentration
- Refills the IAB line without pump interruption
- Removes water condensation from pump tubing automatically without interruption of IABP support
- Adjusts timing for changes in HR
- Alarms and shuts down pump if a malfunction occurs
- Switches to AC or battery power as needed
- Continually sizes ECG and AP waveforms for consistent triggering

These features make IABP initiation rapid and simple. You can then focus on patient care. Using the system controls you can modify:

- ECG and AP sources
  - Zero and Calibrate AP source
  - Turn on AP alarm
  - Select AP scale or Autoscaling
- Select the Operations mode
- Start and Stop Counterpulsation
- Adjust IAB volume
- Turn the alarms (Gas Surveillance) ON or OFF or Reset and alarm
- Select Trigger Mode (Operator mode only)
- Set Timing (Operator mode only)
- Start/Stop recordings and define recorder settings
- Use cursor to assess patient and pump parameters
- Select the assist ratio
- Obtain key and mode specific help as well as start up instructions
- Turn arrhythmia timing On or Off
- Freeze the waveform display

### 3. Principles of Operation

#### 3.1: Overview of the AutoCAT™2 Series



Figure 3.1: The AutoCAT™2 Series IABP System Configuration

### **3. Principles of Operation**

#### **3.1: Overview of the AutoCAT™2 Series**

---

#### **AutoCAT™2 Series Control Module**

The AutoCAT™2 Series has a detachable control/display module, housing the LCD that shows all of the information you will monitor during pump operation and the function control keypad. The control/display module is mounted on a bracket and connected to the pneumatic drive module by a twelve foot (3.6m) cord. The control module can be fully rotated 360°, with the base, raised upright to any position desired, or detached for placement on an IV pole display mount.

#### **To rotate or change the viewing angle of the control module:**

1. Press the silver button located on the rear of the pneumatic unit. The screen will rotate to any position and/or may be locked in 4 positions (90 degree intervals).

#### **To raise or lower the control module:**

1. To raise the control module press the blue button on the control module handle. Raise the display to the desired height. Release the button to lock control head at desired height.
2. To lower control module press the blue button and push the handle down to desired position. Release button to lock.

#### **To detach/attach the control module from the IABP drive module:**

1. Reach behind the control module to the central section.
2. Squeeze the dark blue handle.
3. Lift the module straight up to clear the mounting bracket.
4. To reattach control module, place it over the locating pins and push down until a click is heard, indicating it is locked in place.

#### **To tilt the control module up or down:**

1. Move the control module to the desired position by pushing or pulling it.
  2. If the control module moves when keys are pressed, you can tighten the adjustment by turning the knob on the lower right side of the display.
- To allow for viewing of the LCD during transport, position the control module so that it lays flat and face up in the well on top of the AutoCAT™2 Series.



*Figure 3.2: The AutoCAT™2 Series LCD and Control Function Keypad*

#### **To place the control/display module on the IV Pole Display Mount:**

1. Detach the control module from the IABP drive module.
2. Slide the control/display module down over the mounting bracket on the IV Pole Mount.
3. The control/display module is secure when a click is felt.

**To place the control/display module on the IABP drive module:**

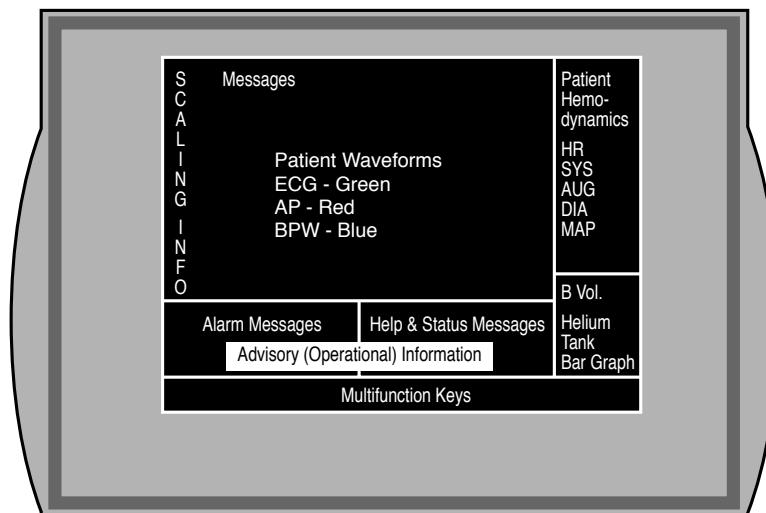
1. Position the mounting bracket on the IABP drive module to any position.
2. Slide the control/display module down over the mounting bracket on the IABP drive module until it clicks into place.

**WARNING**

Do not transport the AutoCAT™2 Series in an aircraft with the control module in the upright position. The control module must be positioned down, flat to the pump module prior to transport, or the control module may be removed from the pump and carried.

**AutoCAT™2 Series Display**

The AutoCAT™2 Series LCD display layout has been organized to provide easy identification of information available on the LCD. The LCD is divided into areas where specific information will be displayed. Several areas may have more than one display characteristic while other areas are dedicated to specific waveforms or information.



*Figure 3.3: Screen area definitions*

The high resolution, color LCD shows three waveforms, each in a different color for easy identification and interpretation:

- Calibrated ECG trace (green, superimposed with white during assist intervals)
- Calibrated Arterial Pressure waveform - red, superimposed with white on UNASSISTED beats, in Operator Mode.
- Calibrated Balloon Pressure waveform (blue)

The blue horizontal scale at the bottom of the LCD shows different information depending on the Operation mode selected:

AutoPilot™ mode: No timing bar will be displayed. Information on current timing settings, Arrhythmia detection and Arrhythmia timing OFF is displayed. The timing settings are updated periodically and are displayed in % or Msec., depending on the automatically selected trigger mode.

### **3. Principles of Operation**

#### **3.1: Overview of the AutoCAT™2 Series**

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**Operator Mode:** When the Operator mode is selected the Timing bar displays the inflation/deflation range and current timing settings.

This range is 0% to 120% of the R-R interval for all trigger modes. The distance between vertical lines represents 10% of the R-R or AP interval. An expanding green or red bar indicates the inflation and deflation set points. This bar changes to red during Arterial Pressure triggering. The bar changes to yellow if deflation timing is set beyond 100% (100% to 120% only).

The patient's physiological data is displayed in white alphanumeric characters for assisted beats. This data is calculated and displayed on a beat-to-beat basis. Heart Rate is averaged over two seconds. In addition, a heart-shaped symbol flashes each time the system detects a trigger point. Physiological data that is displayed includes:

- HR (Heart Rate, in BPM)
- SYS (Systolic pressure, in mmHg)
- AUG (Augmentation, in mmHg)
- DIA (Diastolic Pressure, in mmHg)
- MAP (Mean Arterial Pressure, in mmHg)

When the Assist ratio is 1:2 or lower, the Unassisted AP values appear continuously in YELLOW below the Assisted value.

Other operating information displayed includes:

- Balloon Volume (Current set volume. This is automatically set from the IAB connector or can be changed by the user.)
- HE (remaining helium pressure in the tank, bar graph display in PSI)
- ALARM STATUS (on or off)
- LightWAVE™ sensor status: A lightbulb is displayed in the AP scaling area. The color of the lightbulb alerts the user as to the current status of the LightWAVE™ AP sensor. (See page 3-30 for details).
- Trigger Signal (flashing heart symbol and white highlights on green ECG trace)
- Trigger mode (Displayed under the HR) The color of the trigger mode matches the associated waveform. Internal trigger is displayed in YELLOW.
- Diagnostics (alphanumeric messages)
- ECG/Source/Lead and Gain State (AUTO or MANUAL)
- Arterial Pressure/Balloon Pressure Waveform Scales
- Operation mode selected: Displayed above the ECG waveform in Yellow and by LED's on the key.
- Warning messages: These include, Battery Operation, Weaning Selected, Alarms Off and Operations Mode selected.
- Cursor (magenta)

Around the LCD is the control function keypad. These control keys allow you to select all operating functions needed to run the AutoCAT™2 Series. The control keys are labeled individually with their corresponding function. Similar functions are grouped together. In addition, the power switch is located on the front of the console (shown in Figure 3.4). The operating functions of the displays and control keys are explained in detail in Sections 3.3 and 3.4. The control keys are grouped into the following categories:

- ECG Source Select - ECG Skin /Monitor
- AP Source Select - Fiber Optic (LightWAVE™ sensor)/Transducer /Monitor
- Operations Mode: AutoPilot™ or Operator
- Inflate/Deflate Timing Controls
- Pump Status
- Alarms Reset and ON/OFF
- Recorder
- Freeze Display
- Balloon Volume
- Assist Ratios
- Help
- Home
- Trigger
- Arrhythmia Timing: ON/OFF
- Multi-Function Keys

Seven additional multi-function keys are located under the LCD display and correspond to the operation indicated directly above the key on the LCD.

The multi-function key legends change in response to certain operating key presses. These include:

- ECG Source select (ECG Lead Select and gain control)
- AP Source Select (Zero/Calibration/AP Scale/AP Alarm/Autoscaling ON or OFF)
- Alarms OFF (select time for alarms to be disabled)
- Balloon Volume (Volume Controls)
- Trigger Mode (Seven trigger modes) Operator mode only.
- HOME (additional operating controls)

These keys will automatically return to the normal functions after 30 seconds, or immediately when the HOME key is pressed. The currently selected function is highlighted in reverse video.

### 3. Principles of Operation

#### 3.1: Overview of the AutoCAT™2 Series

#### Patient Connections

The front of the console contains the balloon connector and all of the input and output connections required to receive the signals from the patient or bedside monitor that allow the control system to analyze the patient's status.



Figure 3.4a: AutoCAT™2 WAVE



Figure 3.4b: AutoCAT™2

#### AutoCAT™2 WAVE Connectors

The AutoCAT™2 WAVE has an additional set of connectors on the second tier. These are the connectors for the LightWAVE™ AP Sensor and CAL Key.

**NOTE:** These connections may only be used with LightWAVE™ Series Arrow IAB catheters.

### **Storage Compartment**

The top panel contains a compartment for storage of paper and other small accessories.



*Figure 3.5: Top Panel Storage Compartment*

### **AutoCAT™2 Series Pak**

May be attached to the side handles and be used to store accessories such as cables, operator's manual and helium. A clip at the bottom of the pak attaches to the lower panel of the AutoCAT™2 Series and holds it in place.

### **3. Principles of Operation**

#### **3.1: Overview of the AutoCAT™2 Series**

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#### **Pneumatic Drive Module**

The pneumatic drive module contains the pumping system needed for IABP operation. A 500 psi disposable or 2000 psi refillable/disposable helium tank is housed in a compartment at the left rear of the pneumatic drive unit. The front of the module contains the power switch, balloon connector, AC indicator lamp and a battery charge lamp, all of the input and output connections required to receive the signals that allow the control unit to analyze the patient's status. Also a flash card receptacle, modem connection RS 232, and simulator connector are available. The pneumatic drive unit has four 360 degree swivel wheels which can be locked into position by depressing the pedal, located in the center of each wheel. This is designed to minimize IABP configuration for transport.

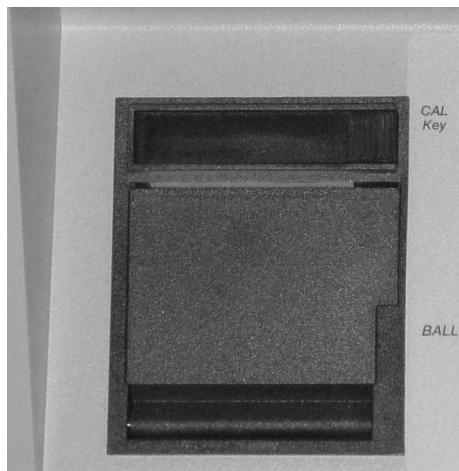
The AutoCAT™2 Series also has a thermo-electric baffle system (cold trap) to condense and remove moisture from the pneumatic lines. This is to prevent moisture from collecting in the tubing, where it will impede the flow of helium. Moisture is chilled and condensed into liquid. The liquid drains into a condensate collection bottle in the helium storage compartment behind the helium tank.

#### **System Battery**

The AutoCAT™2 Series battery system is located inside the pneumatic drive module and the circuit breaker is located in the helium storage compartment. The AutoCAT™2 Series battery system allows you to use the system with full operational capabilities for a minimum of 90 minutes in case of AC power failure. An optional battery can be added to the unit to increase battery operating time to a minimum of 180 minutes. The system automatically switches to battery power when AC power is removed. Warning messages appear when the DC circuit breaker is off, and when 20, 10 and 5 minutes of battery power remain. The batteries recharge automatically whenever the system is connected to AC power. **Recharging completely discharged batteries requires about eight hours, but 80% of the batteries' charge is restored within four hours.** A yellow indicator light is located on the front panel to show when 80% battery charge is available. Protective circuitry prevents overcharging. The green light labeled "Power Indicator" on the AutoCAT™2 Series front panel will illuminate when the AutoCAT™2 Series is plugged into AC power. More information regarding the system batteries, how to test the batteries, and how to replace the batteries is found in the Maintenance Section of this manual, section 6.1.

### **Strip Chart Recorder**

A strip chart recorder is located on the front of the console. This dual-channel annotating recorder uses 50mm-wide thermally sensitive paper and will record up to two waveforms simultaneously: ECG, AP and Balloon Pressure. Bars across the top of the recorder strip show assist intervals. The patient's assisted and unassisted hemodynamic data is also recorded, along with current alarm messages, IAB volume, operations mode, timing mode, assist ratio, trigger mode, assist markers, ECG source, AP source, AP/BPW scale, AP alarm status and date and time. The recorder can be turned on or off at any time during operation. Certain alarms (discussed further in Section 3.3) automatically trigger the strip chart recorder to print approximately the last seven seconds of the Balloon Pressure and AP waveforms and the patient hemodynamic data, current alarm message trigger mode, operations mode, timing mode, AP alarm status, assist ratio, balloon volume, ECG lead, timing settings, date and time. The recorder may be pre-programmed to automatically print approximately seven seconds of waveforms and data at 2 min., 15 min., 30 min., 60 min., 2 hr. or 4 hr. intervals.



*Figure 3.6: The Strip Chart Recorder*

### 3. Principles of Operation

#### 3.2: Input and Output Connections

---

#### Input and Output Connections

The AutoCAT™2 Series will interface with most bedside monitors and can also receive inputs directly from the patient. All input and output connectors are located on the front of the pneumatic drive unit. There are two ECG input connectors (skin, High Level monitor), three arterial pressure input connectors (Fiber Optic LightWAVE™ sensor/transducer and High Level monitor).

Note: The LightWAVE™ AP Signal requires the use of a CAL Key. This receptacle is located next to the LightWAVE™ sensor connector. The CAL Key is provided with each LightWAVE™ Series Arrow IAB catheter.

Three Patient Signal outputs are available for ECG, AP and BPW. The Assist Interval output provides a signal output to a simulator for use during training or testing. Pump information is available via the modem or RS232 serial output, and the Model 2001 simulator may be connected to the RS232 Simulator Connection.

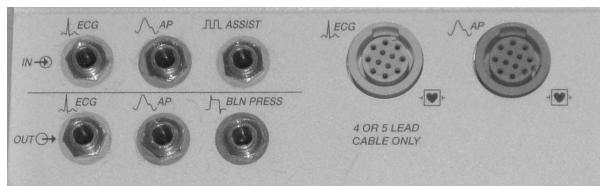


Figure 3.7: Input and Output Connectors

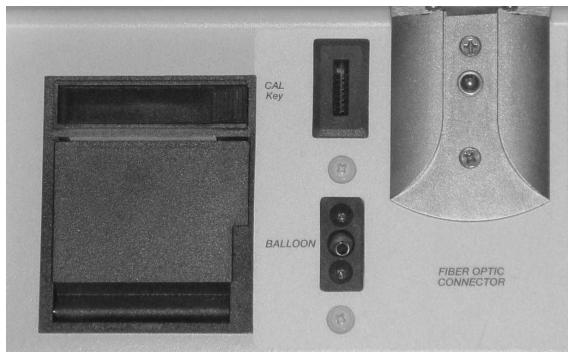


Figure 3.8: AutoCAT™2 WAVE Fiber Optic Sensor, CAL key and balloon connector

**Inputs:** Equipment such as patient monitors which can provide ECG and Arterial pressure signal inputs to the IABP must be in compliance with IEC-601-1 and IEC-601-2-30.

- Patient simulators which provide ECG, AP and assist signal inputs used in training and operational check-out of the AutoCAT™ Series must meet IEC60950 requirements.

**Outputs:** The AutoCAT™ Series can output ECG, AP and Balloon pressure signals as well as RS232 serial data to recorders, simulators, computers or bedside charting systems. These devices must meet IEC60950 requirements.

A clear plastic cover is available (P/N 2800-92-64003) to cover and protect unused I/O jacks. These may be easily inserted and removed from the pump.

## **Input Connections**

Input connectors are used to provide one or more signals to the AutoCAT™2 Series System:

- an ECG signal from an ECG monitor or directly from the patient
- an AP signal from an AP Fiber Optic (LightWAVE™) Sensor mounted in the IAB, a monitor or transducer

The AutoCAT™2 IABP system should be connected to at least one ECG and one AP source. This is very important when the AutoPilot™ mode is selected since it gives the pump more options and information to maintain appropriate triggering and timing. In both the AutoPilot™ and Operator mode having an ECG and AP signal available will display the patient hemodynamic status. Connection of both an ECG and AP signal are highly recommended even when the Operator mode is selected. When these connections are made, ECG and AP waveforms are displayed on the LCD, allowing you to monitor the effects of counterpulsation.

There are two types of input connectors. “High-level monitor” inputs are Phone connectors that receive signals from monitors. “Low-level” inputs receive signals from ECG patient cables and pressure transducers. In addition, on the AutoCAT™2 WAVE, a special connection is available for a High fidelity AP signal which is available on some Arrow IAB catheters. This Fiber Optic (LightWAVE™) AP signal provides the best signal quality and fastest set up of all AP sources and requires no maintenance. **Direct ECG/AP connection from the patient to the AutoCAT™2 Series is preferred. AP LightWAVE™ sensor is always the preferred signal when it is available.** Cables are available from Arrow International. See Section 6.2 for ordering information.

**NOTE:** It is important that the monitor output signals for ECG and AP are compatible with the AutoCAT™2 Series. Some monitors require special modules to output this information. Be sure you have the correct equipment and cables available.

### **CAUTION**

Only Fiber Optic sensors provided with Arrow International IAB catheters should be used with the AutoCAT™2 WAVE. Use of other Fiber optic sensors may cause damage to the IABP system or produce inaccurate AP readings.

### **3. Principles of Operation**

#### **3.2: Input and Output Connections**

<b>Input Connectors</b>	
ECG MON input jack (1/4" Phone) green ring	Phone jack for accepting ECG signals ( $\pm 6$ volts DC maximum) from a remote monitor. Input to this jack is displayed on the green ECG (top) line of the AutoCAT™2 Series waveform display. CAUTION: Pacer output must be available from the bedside monitor for pacers to be detected and displayed by the AutoCAT™2 IABP. Check the setup of the bedside monitor to insure pacer output is turned ON, when pacer detection is required.
ART PRESS input jack (1/4" Phone) orange ring	Phone jack accepts signals (up to $\pm 6$ volts DC, 100mmHg/volt) from a remote Arterial Pressure monitor. Input to this jack is displayed on the red Arterial Pressure (second) line of the AutoCAT™2 Series waveform display. Output of the remote monitor must be calibrated at 100mmHg/volt.
ECG patient electrode cable connection via ECG cable	Green Nicolay connector for patient ECG cable. Input to this connector is amplified by the AutoCAT™2 Series and displayed on the green ECG. 4 or 5 lead cables only.
ARTERIAL PRESSURE Transducer cable connection	Orange Nicolay connector for an Arterial Pressure Transducer (use only Spectramed transducers or their electrical equivalents, i.e. 50 $\mu$ V/V/cm Hg). Input to this connector is amplified by the AutoCAT™2 Series and is displayed on the red Arterial Pressure (second) line of the AutoCAT™2 Series waveform display.
ARTERIAL PRESSURE LightWAVE™ Fiber Optic Sensor (AutoCAT™2 WAVE only)	The AP LightWAVE™ sensor has two connections. The first is the actual LightWAVE™ sensor light source and sensor. This is a slide on the second tier of connections on the Right side of the pump driving unit. To connect the AP LightWAVE™ sensor signal, orient the connector attached to the IAB with the arrow facing outward and slide the connector into the grooves. The connector will only fit one way. Slide the connector into the receptacle and press the connector until it clicks. The click insures the connector is fully seated in the receptacle.
CAL KEY (AutoCAT™2 WAVE only)	Attached to the AP LightWAVE™ sensor is a calibration key. This contains important information about the LightWAVE™ sensor. After the LightWAVE™ sensor is connected to the IABP, connect the CAL key in the receptacle next to the IAB connector. NOTE: If this key is not inserted, a message will appear on the display: CAL KEY Missing.  CAUTION: The LightWAVE™ sensor will not work properly without the calibration key. The calibration key must be connected to properly zero the sensor and provide the correct calibration information to the pump. The calibration key must not be changed during use of the sensor. Using a calibration key other than the one supplied with the IAB may result in incorrect AP readings.

## Data Connections

Data connections allow information from the pump to interface with external devices such as simulators and data management systems.

Data Connections	
Flash Card	PCMCIA standard flash card will provide selected (alternative) start-up settings and provide storage for QA log.
Modem	Provides real time output of all information to remote computer for monitoring or troubleshooting assistance.
RS 232	DB-9 connector provides a serial transmission of hemodynamic values, current alarms time and date.
Simulator	DB-9 connector provides power and assist information as well as ECG and AP signals to the Model 2001 Simulator.

## Output Connections

Output connectors allow you to output signals for display on an external monitor (“low-level” input signals must be used to do this) or use with an interactive simulator.

Output Connectors	
ECG output jack Series (green ring)	Phone jack provides signal for displaying or recording the AutoCAT™2 ECG trace on an external monitor. (Maximum output: ±5 volts DC.)
ART PRESS output jack (orange ring)	Phone jack provides signal for displaying or recording the AutoCAT™2 Series Arterial Pressure trace on an external monitor. Output is calibrated at 100mmHg/volt.
BLN PRESS output jack (blue ring)	Phone jack provides signal for displaying or recording the AutoCAT™2 Series balloon pressure trace on an external monitor. Output is calibrated at 100mmHg/volt.
ASST INT (yellow ring)	Phone jack provides a signal for use with an interactive simulator (used for training or testing purposes).

## Balloon Connection

The input labeled BALLOON connects the IAB's helium supply line to the AutoCAT™2 Series. The AutoCAT™2 Series accepts Arrow International's electronically-coded balloon connectors, which automatically set pumping volume to match the balloon's maximum volume capacity. This connector also limits the amount of helium which can be delivered to the IAB to the IAB's maximum volume.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

#### Function Control Keys

The AutoCAT™2 Series keypad includes nineteen (19) operation control keys and seven (7) multi-function keys. The following pages describe each section of the control keypad and individual key functions. Each section will detail the operation of the function in the AutoPilot™ and Operator modes. The function control keypad display is pictured in Figure 3.9. Control keys and selections are explained in the order of their appearance on the control module from top to bottom. Preset selections are bracketed in this text for clarity.

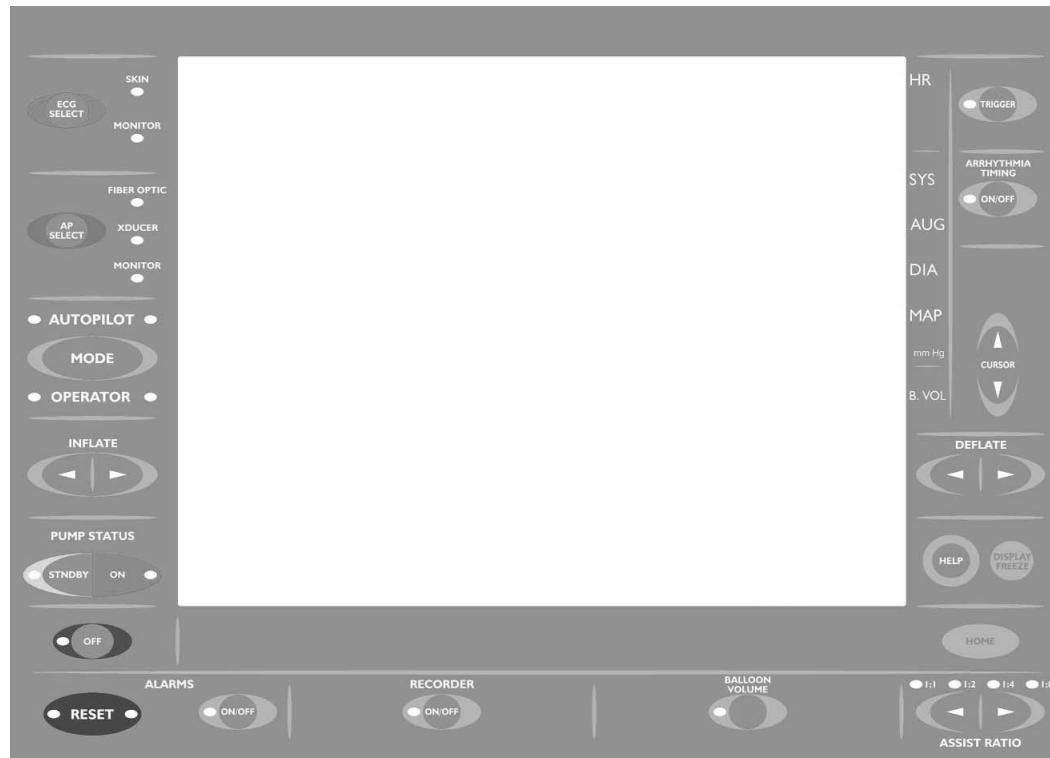
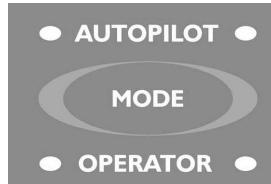


Figure 3.9: Front panel of control/display module.

### 3. Principles of Operation

#### 3.3: Control Keys and Functions Keys



#### AutoPilot™/Operator Mode Control Keys

The main function key is the OPERATIONS MODE key, which selects either AUTOPILOT or OPERATOR mode. The user should choose the operation mode prior to setting up the AutoCAT™2 Series for patient use. The LED's indicate the selected mode.

**AutoPilot™ (Default mode):** When AutoPilot™ mode is selected the AutoCAT™2 Series will automatically select and change ECG and AP sources, trigger mode and timing settings to maintain optimal counterpulsation.

**Automatic Signal source selection:** When the AutoPilot™ mode is chosen, the pump will monitor and analyze all available ECG and AP signals. It will select either the best signal as determined by several factors or the first available signal if only one signal is present. If all signals are similar, then ECG Skin, Lead II and AP LightWAVE™ are the preferred signals. If a signal is lost or becomes erratic, the pump is continuously analyzing all other signals in the background. It will choose the best signal from those which are available. The system is designed to maintain optimal triggering whenever possible. If triggering cannot be maintained a Trigger Loss alarm will be issued.

**Automatic timing:** The pump determines the optimal timing method and timing settings based on the signals which are available and then based on further analysis of the ECG/AP and BPW waveforms. The system can detect irregular rhythms and implements special timing algorithms for these circumstances. The following table shows the timing methods and signal which are needed:

#### INFLATION TIMING METHODS

WAVE™ algorithm (AutoCAT™2 WAVE only)	ECG AP LightWAVE™ sensor (with or without ECG)
Predicted inflation	ECG AP Transducer or Monitor
Weissler Inflation	ECG only

#### DEFLATION TIMING:

Predicted deflation	ECG AP (Any source) No Arrhythmia or Arrhythmia timing OFF
R wave deflation	ECG AP any source (AP not required for R wave deflation) Arrhythmia detected and Arrhythmia timing ON
Weissler deflation	ECG only Arrhythmia Timing OFF

### **3. Principles of Operation**

#### **3.3: Control Keys and Function Keys**

---

#### **Timing method description:**

##### **AutoPilot™ Mode**

##### **Inflation Timing Methods**

**WAVE™ Inflation Timing:** This exclusive algorithm uses the AP signal from the LightWAVE™ sensor to calculate aortic flow. From the flow wave, the aortic valve closure (AVC) point can be determined. The algorithm sets the inflation to the point of AVC. This method monitors the patient in real time, on a beat to beat basis and adjusts the IAB inflation time accurately during both normal rhythms and severe dysrhythmia. This method is available with or without an ECG signal present.

**Predicted Inflation:** This method uses the ECG and AP signals and adjusts the inflation timing to produce a "V" at the IAB inflation point on the AP waveform.

**Weissler Inflation:** Weissler's formula calculates the Systolic Time Interval (STI) based on the HR. The appropriate inflation setting is then determined.

The inflation methods are listed in descending order by accuracy. The WAVE™ method is the most accurate.

##### **Deflation timing methods:**

**R Wave:** Deflation occurs when the R wave is detected. This occurs on beat to beat basis, in Real time to allow adjustment of the length of IAB inflation to match the diastolic cycle length. This timing mode is selected when arrhythmia is detected and arrhythmia timing is on.

**Predicted deflation:** This method sets deflation to occur prior to the AP upstroke or mechanical systole. The ECG, AP and BPW waveforms are analyzed to produce the optimal end diastolic pressure drop.

**Weissler deflation:** Deflation is predicted based on the HR only. Weissler's formula calculates the systolic time interval and is able to set the approximate deflation time when ECG only is available.

#### **WARNING**

Automatic timing in AutoPilot™ mode may not be appropriate in all patients. The clinician should monitor the AP waveform to determine the accuracy of timing. If timing is not appropriate in AutoPilot™ mode, select Operator mode and set timing manually.

**NOTE:** Inflation and Deflation Timing controls are not available when AUTOPILOT is selected. To set timing manually, choose OPERATOR mode.

**Operator mode:** When the Operator mode is selected, the user has control over most pump functions and can select the trigger mode, signal source and timing. The settings will not be changed by the pump. Timing is set by the user with automatic changes to compensate for changes in HR up to 25%. Preset safe timing is selected in each trigger mode as the default settings. Timing can be set independently for each trigger mode.

### Inflate/Deflate Control Keys

#### AutoPilot™ Mode:

Not functional. Timing is set automatically based on physiologic information from the patient and the available signals.

#### Operator Mode:



### Inflate / Deflate Control Keys

INFLATE	Adjusts the inflation point (seen as a green or red bar at the bottom of the LCD); inflation occurs later when the right arrow is depressed and earlier when the left arrow is depressed; allows operator to optimize timing by monitoring the hemodynamic changes produced on the AP waveform.
DEFLATE	Adjusts the deflation point (seen as a green or red bar at the bottom of the LCD); deflation occurs later when the right arrow is depressed and earlier when the left arrow is depressed; allows operator to optimize timing by monitoring the hemodynamic changes produced on the AP waveform.

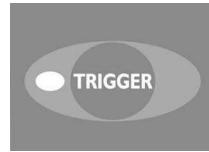
Note: Actual numeric values for Inflate and Deflate settings are given at the end of the timing bar. These represent the percentage (or actual time in msec) of R-R or Arterial to Arterial waveform in which IAB inflation occurs. Timing bar changes to yellow when deflation >100%.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

---

#### Trigger Keys



**AutoPilot™ Mode:** Trigger mode is selected automatically.

NOTE: The criteria for detection of the trigger is listed on page 3-23. The criteria is the same for AutoPilot™ and Operator modes. The trigger mode selection criteria are listed on page 4-5.

**Operator Mode:** The AutoCAT™2 has a trigger key located on the upper right corner of the keypad. This key will display the seven trigger modes in the multifunction keys across the bottom of the display. To select or change the trigger mode, Press TRIGGER, then press the multifunction key under the desired trigger mode. The trigger mode is displayed below the HR value on the right side of the LCD. A complete description of the trigger modes are described on the next page. Trigger mode may be changed while pumping in the Operator mode. Each trigger mode has memory of timing settings specific to that trigger selection. This reduces the need to adjust timing when the trigger selection is changed. When INTERNAL trigger is confirmed, the display will change to the Internal rate adjustment keys.

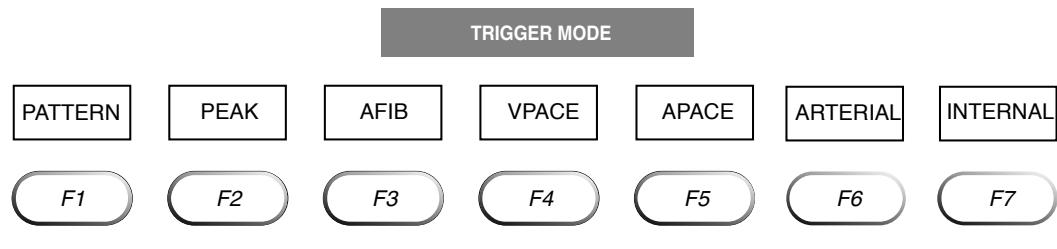


Figure 3.10: Selection of Trigger Mode via the multi-function keys.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

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<b>Trigger Control Key Functions</b>	
<b>Control Key</b>	<b>Description</b>
[PATTERN]	Uses the ECG QR slope, amplitude and width (25-135ms) to define triggers; the most precise ECG trigger, PATTERN is frequently used for patients with routine QRS complexes; may be used with demand pacing.  AutoPilot™ mode: Default trigger. Selected when the HR is < 130 bpm and no arrhythmia is present.
PEAK	Uses the ECG QR slope and amplitude to define triggers; generally used for patients with wide or varying QRS complexes; may be used with demand pacing and may be preferred for HR > 140 bpm.  AutoPilot™ mode: Selected during several conditions. These include HR > 130 bpm and presence of arrhythmia when Arrhythmia timing is OFF.
AFIB	Defines inflation triggers based on PEAK mode, and triggers deflation when the slope of the R-wave begins to rise; generally used for patients with atrial fibrillation, irregular rhythms and tachyarrhythmias (operator cannot adjust deflation point in this mode). Also selected for Real Time Timing. Rejects pacer spikes.  AutoPilot™ mode: Selected when an arrhythmia is detected and the Arrhythmia timing is ON.
VPACE	Uses ventricular pacing spike to define triggers; may only be used for patients with 100% Ventricular or Atrio-Ventricular paced ECG rhythms (A/V interval must be set at 250ms or less).  AutoPilot™ mode: Selected when ECG and AP signals are not available and single or dual pacer spikes are detected. The dual pacer spikes must be within 250 msec of each other to be detected as a pair.
APACE	Uses the atrial pacing spike to define triggers; may only be used for patients with 100% Atrial pacing.  AutoPilot™ mode: Selected when an ECG or AP is present but not stable and the pacer is more than 100 msec before the R wave on the ECG. When the ECG or AP signals are stable, the pump will select and ECG or AP trigger mode.
AP	Uses rising slope of AP waveform (with blanking for the balloon) to define triggers; may be used when changing electrodes; for patients with 100% pacing; or when interference prevents use of ECG triggers; this mode should not be used for patients with A Fib or tachyarrhythmias.  AutoPilot™ mode: Selected when ECG is noisy or not available.
INT	Rate is set by the operator and external patient signals are ignored; this selection automatically changes RATIO to 1:1. Preset Rate is 80 BPM. The multi-function keys change when internal trigger is selected to allow internal rate to be changed.  AutoPilot™ mode: Not available.  The internal trigger mode should only be used if the patient has no myocardial activity and/or ventricular ejection. You must select Operator mode, then Trigger mode and INTERNAL twice to select this trigger mode. An audible alert will sound when a valid ECG is present and INTERNAL mode is selected. Evaluate the ECG and AP signals and select an ECG or AP based trigger as soon as possible.

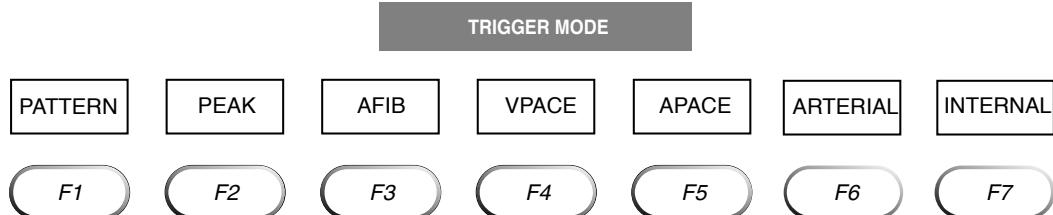
### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

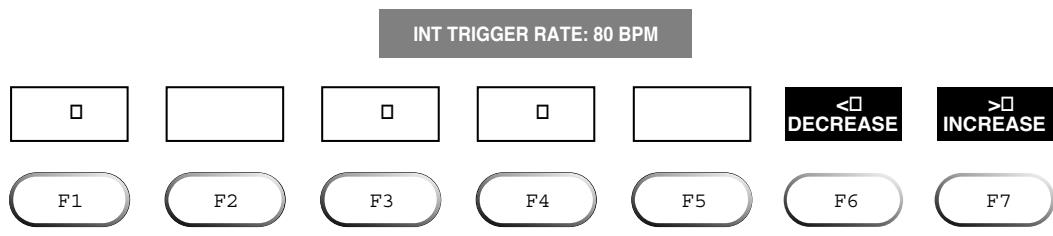
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##### Internal trigger mode selection

- To select INTERNAL trigger mode:
- Select Operator mode
- Press TRIGGER key
- Press INTERNAL in the multi-function keys



- 
- Press INTERNAL again to confirm, then the following multi-function keys will allow the Internal rate to be changed:



### Arrhythmia Timing ON/OFF

Arrhythmia Timing Control Key (AutoPilot™ mode only)



**AutoPilot™ Mode:** The Arrhythmia timing key selects whether R wave deflation is automatically implemented when an arrhythmia is detected. The default selection is ON. The LED is lit when the function is ON. When the Arryhytmia timing function is ON, the pump will automatically select R wave deflation (AFIB) trigger mode when an arrhythmia is detected.

When the Arrhythmia timing key is OFF, the pump will not select R wave deflation even when an arrhythmia is detected. The LED will be OFF and a message displayed in the timing bar area. In the AutoPilot™ mode, the pump will select the PEAK trigger mode in this case.

Arrhythmia timing key is only active in AutoPilot™ mode. The user can select any trigger mode in Operator and deflation timing will be based on this selection.

**Operator Mode:** Not available.

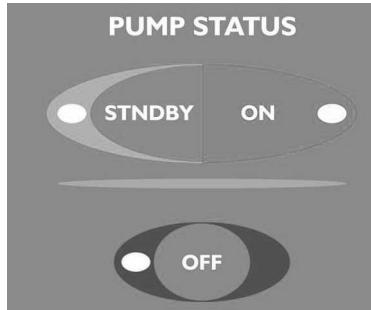
**Note:** If R wave deflation is desired in OPERATOR mode, select AFIB trigger.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

#### Pump Status

##### AutoPilot™ and Operator Modes:



Pump Status Control Key Functions	
Control Key	Description
ON	Fills the pneumatic system with helium to 2.5mmHg, and starts pumping; if pressed before PUMP STNDBY, pumping starts after one purge cycle. The pump will monitor the speed of the IAB inflation and deflation and do a series of purges to improve helium concentration (IAB speed) as needed.
STNDBY	If pump is on, immediately stops pumping but does not vent the pneumatic system; if pump is off, completes a four beat purge cycle and pressurizes the pneumatic system to 2.5mmHg; four alarms (described later in this section) cause the pump to go into standby mode.
OFF	Immediately stops pumping, deflates the balloon and vents the pneumatic system to atmosphere; six alarms (described later in this section) automatically stop the pump.

#### CAUTION

The OFF button under PUMP STATUS indicates a condition where the pump has stopped and the patient is not receiving IABP support. PUMP OFF should be used only under direct clinical supervision. The pump should be re-started as soon as possible to prevent thrombus formation on the surface of the IAB.

When PUMP ON is pressed the first time after powerup, the AutoCAT™2 Series purges the pneumatic system of ambient air for three cycles which consist of a purge beat followed by 10 mixing beats. This results in optimal Helium concentration at start-up. When the pump is ON, a pressure transducer in the internal helium line monitors the action of the stepper motor and bellows. This transducer is the source of the balloon pressure waveform displayed on the AutoCAT2 Series display. The system monitors the BPW for speed of inflation and deflation and will re-purge as needed to maintain optimal performance. If a small helium leak exists, the AutoCAT™2 Series will automatically refill the IAB line without interrupting pumping. If larger leaks are detected, the AutoCAT™2 Series alarm system will shut down the pump.

NOTE: The alarms must be ON for automatic condensate removal and IAB refills to occur.

## Signal Input Selection



### ECG Signal Source

#### AutoPilot™ and Operator modes:

The ECG Signal source Control Key allows you to select the input source for the ECG. There are two methods of connecting the ECG to the pump. These are:

1. ECG Skin using the Direct ECG Cable (4 or 5 Lead) or Backpad ECG. Select SKIN and the desired lead. Available lead settings will appear in the multifunction keys, based on the type of ECG cable connected to the AutoCAT™2 Series.
2. Phone to Phone (High Level Slave from bedside monitor). Select MONITOR under ECG Select and verify the MONITOR LED is lit. ECG lead displayed on the AutoCAT™2 Series will be the lead selected on the bedside monitor. When lead is changed on the bedside monitor it will also change on the pump although MON is displayed on the LCD (AutoCAT™2 WAVE Series have pacer detection available via this connection if the pacer output is available from the bedside monitor).

#### ECG Skin:

When the ECG Skin is selected and the ECG SELECT key is pressed, the multi-function keys will change to reveal the lead selections, which are available to the pump. The number of leads will depend on whether a 4 or 5 lead ECG cable is used. When either of these cables is connected to the AutoCAT™2 Series, the type of cable, and therefore the ECG leads available is automatically recognized. Therefore, Leads I, II, and III are available with the 4-lead cable and I; II, III, aVR, aVL, aVF and V are available from the 5 lead cable.

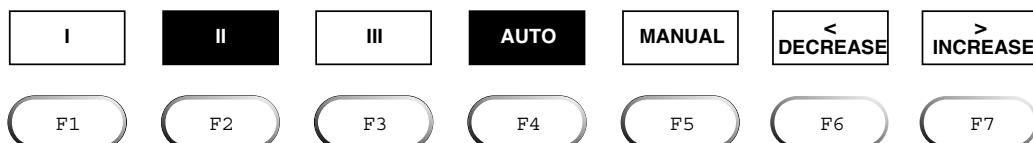


Figure 3.11: ECG Lead Selection (4 lead cable) via ECG Select Key and Multifunction Keys

#### CAUTION

Do not use a 3 lead ECG cable or Phono to Nicholay slave cables. The 3 lead ECG cable and Phono to Nicholay cables will not work properly with the AutoCAT™2 Series.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

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The default lead is lead II for all cables and operation modes, when SKIN input is chosen. The lead selected is displayed in the upper left corner of the LCD display. To change the ECG lead, press ECG SELECT so the leads are displayed and then press the multifunction key under the desired lead. The reverse video highlight will indicate your new selection and the lead displayed on the LCD will indicate the new lead selected.

When the 5 lead ECG cable is in use, two ECG leads are displayed in the first 3 multi-function keys (see Figure 3.12). When selecting leads for the 5-lead cable, the active lead is always displayed in the upper portion of the multifunction key. If the desired selection is in the lower half of the multifunction key, you must press the Multi-function key until the desired lead is in the upper portion of the multi-function key and is highlighted in white. The lead displayed on the LCD should match this selection.

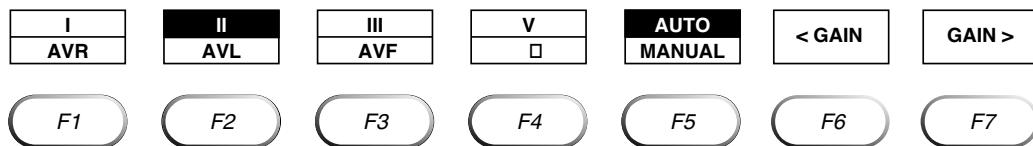


Figure 3.12: ECG Selection (Skin) with 5 Lead ECG cable.

**Lead selection in AutoPilot™ mode:** When the AutoPilot™ mode is selected, the user can still change ECG leads, sources and gain control. However, in the case of ECG leads and sources, the AutoPilot™ mode will automatically change the selection to maintain optimal IAB counterpulsation as needed. If the user does not want the pump to automatically change ECG leads and/or sources, select Operator mode.

**ECG Mon:** If you wish to change the input to the direct monitor input, using the Phone to Phone cable, simply press the ECG SELECT key a second time and the LED will indicate that the selection is now MONITOR. The lead displayed on the AutoCAT™2 Series will be the same as the bedside monitor.

### ***ECG Gain Control —***

#### ***AUTO GAIN Mode (AutoPilot™ and Operator Mode)***

Autogain of ECG signal functions continuously, so there is normally no need to adjust the ECG size. In this mode, the AutoCAT™2 Series will optimize the gain required by the pump. In most cases this will result in a stable ECG trigger. If the ECG is biphasic or varies significantly from beat to beat, you may use the < or > keys to increase or decrease the AUTOGAIN level. If a stable trigger cannot be established you may want to use the MANUAL mode. If the AutoCAT™2 Series is missing some QRS complexes and those beats are smaller than the average QRS complexes, the > GAIN key may be used in the AUTO mode to increase the size of ALL beats.

If the AutoCAT™2 Series is double triggering on some QRS complexes or P and T waves and those beats are larger than the average QRS complexes or P and T waves, the <GAIN key may be used in the AUTO mode to decrease the size of ALL beats.

***Note:*** *If the AUTOGAIN target level is changed, (increased or decreased) the change remains in effect until you change the ECG lead. When the ECG lead is changed, whether automatically or by the user, AUTOGAIN resets the size to the optimal level. You should reassess the triggering and adjust the AUTOGAIN target level if the situation so dictates. Even upon return to the previous lead, AUTOGAIN will be reset to the optimal target level and may need to be readjusted.*

#### ***MANUAL Gain Mode (AutoPilot™ and Operator Mode)***

In some clinical situations such as transport or in the Operating room, the ECG may be so variable that AUTOGAIN will not produce stable triggering. In rare cases, this may also occur with very large abherent beats, such as PVC's.

If this situation occurs, you may select the MANUAL gain mode. In this mode, the ECG size will change only when a new lead/ECG Source is selected or when the <GAIN or >GAIN keys are pressed. This may result in improved triggering under these conditions.

It may also be helpful to change the ECG lead to minimize the difference between the size of different QRS complexes. Verify that there is good lead contact with the skin, which will improve the quality of the ECG waveform and triggering performance of the AutoCAT™2 Series. Autogain and Manual Gain controls have the same function in both AutoPilot™ and Operator mode.

### ***Pacer Detection***

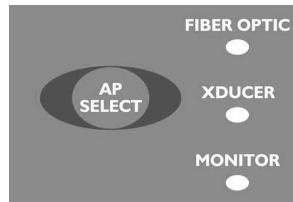
The AutoCAT™2 IABP Series has the ability to detect pacer spikes from the patient or a bedside monitor. Direct ECG skin connection via the 4 or 5 lead cable is preferred when a pacing spike is present. When a slave connection from a bedside monitor to the AutoCAT™2 Series is used, ensure that pacer detection is turned ON at a bedside monitor.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

#### AP Signal Source Select

##### AutoPilot™ and Operator Mode:



The AP SELECT key allows you to select the input source used by the AutoCAT™2 Series for the arterial pressure displayed on the second channel of the LCD. The AutoCAT™2 allows selection between the Transducer and Monitor. The AutoCAT™2 WAVE allows selection between AP LightWAVE™, Transducer and Monitor.

The LED will indicate which source is currently being used by the AutoCAT™2 Series. When the AP LightWAVE™ is available a lightbulb will appear in the AP scale area. The lightbulb will be either Blue or Green. The lightbulb provides information about the state of LightWAVE™:

BLUE: The LightWAVE™ is Not Zero'd.

##### CAUTION

When the FOS icon is BLUE, AP numeric information may not be accurate. Use another AP source for treatment decisions.

GREEN: The LightWAVE™ is Zero'd.

##### CAUTION

If a red X appears through the LightWAVE™ lightbulb symbol an error is present in the LightWAVE™ hardware or sensor. An alternative AP source should be selected.

When AP Select is pressed the multi-function keys will display options to change AP Auto scaling ON or OFF, AP Alarm ON or OFF, Zero and Calibrate the selected signal source. To change the source of the AP signal, press the AP Select key until the desired AP signal LED is lit.

NOTE: The multi-function keys display the same options for AP Autoscaling, Manual Scale selection, Zero and calibration functions in both AutoPilot™ and Operator mode.

NOTE: AP Fiber Optic LightWAVE™ sensor is available on AutoCAT™2 WAVE systems only.

#### LightWAVE™ ICON INFORMATION

ICON COLOR	ZEROED
BLUE	NO
GREEN	YES

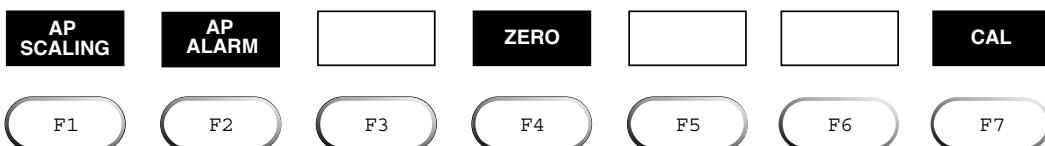
### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

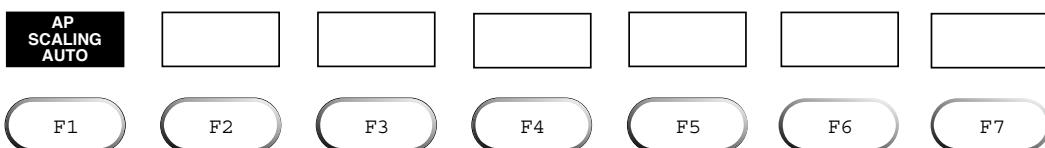
##### **AP Autoscaling: ON (Default setting) (AutoPilot™ and Operator Modes)**

The pump will automatically select the scale which maximizes the display of the AP waveform without clipping either the top or bottom of the waveform. Rescaling will occur within 15 seconds (approximately 2 screens) after the AP waveform has changed. The new scale information will be displayed in the AP scaling area.

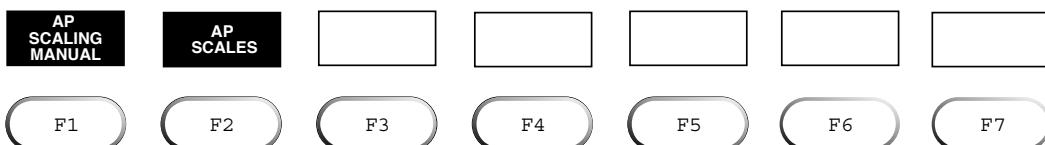
AP Select: Initial display



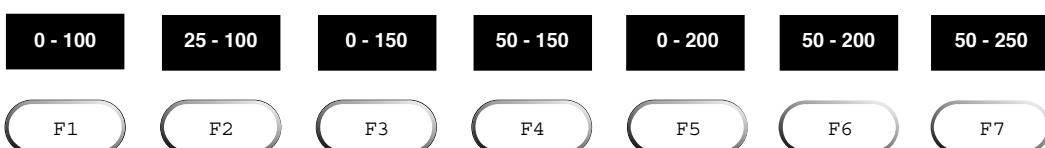
Press AP SCALING and the following keys will appear in the multi-function area



Press AP SCALING AUTO again to select MANUAL scaling the following keys will appear:



Press AP SCALES to display scaling options



##### **Autoscaling OFF:**

If the user does not want the AP waveform to re-scale automatically, select the MANUAL setting in the multifunction keys. When AP SCALING MANUAL is selected the user selectable AP scales will appear. The default scale is 50/150 mmHg or the last scale selected. To change AP scales, press the multi-function key under the desired AP scale.

**NOTE:** If autoscaling is selected, the pump will automatically override the user selected scale. When Autoscaling is ON, additional AP scale selections are available to the pump. Not all selections are available in manual scale selection.

**NOTE:** Autoscoring has more choices available for AP scaling. The manual scaling mode has fewer choices available. Autoscoring may provide better AP waveform visualization.

### **3. Principles of Operation**

#### **3.3: Control Keys and Function Keys**

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##### ***Zero and CAL Function: AP Transducer***

###### **1. To zero the transducer:**

- a. Select the desired AP source
- b. Open the transducer to air
- c. Press ZERO.  
Note: message AP ZERO'D
- d. Close transducer to air

###### **2. To calibrate the AP Transducer**

**NOTE:** Mercury manometer calibration is not necessary except when a reusable transducer is employed. See section 7.1 for a detailed explanation of calibration.

##### ***Zero and CAL Function: LightWAVE™ Sensor***

###### **1. To zero the LightWAVE™ Sensor**

###### **CAUTION**

The LightWave sensor must be zeroed prior to insertion of the IAB into the patient.

- a. Verify the LightWAVE™ sensor is attached to the pump
- b. Connect the CAL Key to the IABP

**NOTE:** Make sure to pull vacuum on the IAB and leave the One-Way valve in place when the IAB is removed from the package. This will maintain a tight wrap.

- c. Remove the IAB from the tray and expose the sensor to room air
- d. The sensor should zero automatically. Verify the LightWAVE™ icon has changed from Blue to Green.

**NOTE:** If the sensor was able to zero automatically the message AP LightWAVE™ SENSOR ZERO'D INSERT IAB will appear. In this case the IAB can be inserted immediately.

- e. If the LightWAVE™ sensor does NOT zero automatically, select the FIBER OPTIC source using the AP SELECT key and press ZERO.
- f. If the FIBER OPTIC source is NOT selected, press the AP SELECT key to select it.

**SELECTING THE AP PARAMETER FOR ALARM  
AND SETTING THE ALARM LIMIT**

Once the AP alarm is on, Multifunction key 3 can be used to select either the MAP or AUG as the parameter for the alarm. Each press of MF3 will toggle between the two selections. MAP is the default settings when the alarm is turned on initially. Once the alarm parameter is selected, the alarm limit can be set (adjusted) by using the < and > alarm limit keys. This is a Low limit alarm and will be issued when the selected pressure falls below the set limit. The default alarms settings are:

Parameter	Initial limit	Alarm limit range
MAP	70 mmHg	30 to 120 mmHg
AUG	100 mmHg	50 to 250 mmHg

The limits can be increased or decreased in 5 mmHg increments.

The current limit will be displayed in YELLOW on the left side of the LCD, between the AP Scale information.



The following message will appear when the < and > limit keys are pressed:

"INCREASE OR DECREASE CURRENT ALARM LIMIT  
CURRENT ALARM LIMIT: XXX MMHG"

AP alarm information, ON/OFF, AP parameter selected and AP alarm limit will be printed on the recorder strip.

**CAUTION**

The alarm limit should be set low enough to reduce the risk of intermittent alarms due to minor changes in the patient condition, but not so low that serious deterioration of the hemodynamic status is not detected.

### **3. Principles of Operation**

#### **3.3: Control Keys and Function Keys**

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##### **ALARM CONDITIONS**

When the MAP or AUG is below the alarm limit for a specified period of time, a Class 3 Alert will sound and the following message will be displayed:

##### **ARTERIAL PRESSURE ALARM**

##### **ARTERIAL PRESSURE HAS FALLEN BELOW SET LIMIT:**

- 1.CHECK AP FOR DISCONNECT**
- 2. ASSESS PATIENT HEMODYNAMICS**
- 3. RESET ALARM LIMIT**

The time to alarm will vary depending on the parameter selected for the alarm and the assist ratio of the pump.

**MAP:** The MAP alarm will be issued when the MAP is below the alarm limit for 8 consecutive seconds. This alarm is available when pumping and when not pumping.

**AUG:** The AUG alarm is only available while pumping, since this is the only time the AUG is present. If the pump is in 1:1 or 1:2 assist, the alarm will be issued when the AUG is below the alarm limit for 5 consecutive beats. When the assist ratio is 1:4 or 1:8 the alarm will be issued within 30 seconds, independent of how many assisted beats have occurred. This will prevent alarms on 1 or 2 assisted beats only.

The alarm will automatically reset if the selected parameter goes above the alarm limit. The user can also reset the alarm manually by pressing the RESET key. If the alarm has been manually reset and the AP parameter remains below the alarm limit for 3 consecutive minutes, the audio alarm will sound again. The alarm message will remain on the screen as long as the alarm limit is violated.

It is important to assess the patient hemodynamics and also check for disconnects in the AP set-up. If the alarm limit is too high, the user should consider resetting the limit. If you change AP SOURCE during the AP alarm, and the new AP source is above the alarm limit, the alarm will be reset. It is important to check the original AP SOURCE where the alarm was detected to verify that no disconnect has occurred.

##### **CAUTION**

If the AP alarm is being used primarily to monitor for AP disconnect, the MAP should be used, as the alarm is available when the pump is pumping and when the pump is not pumping. The AUG alarm is only available when the pump is pumping. This may not alert the user to disconnection under all conditions.

##### **CAUTION**

Switching the AP SOURCE during an AP alarm could reset the alarm even if a serious condition, such as a tubing disconnection has occurred. Even if the alarm has been reset, the user should verify that the AP source (transducer or monitor) lines are intact and that bleeding from the source of the AP alarm has not occurred.

### **Assist Ratio**

#### **AutoPilot™ and Operator Modes:**



The ASSIST RATIO control keys are used to select the frequency of IABP assist the patient will receive. Counterpulsation is usually initiated in a 1:1 ratio in AutoPilot™. Using the left or right arrow keys you can choose your selection. The ASSIST RATIO can be selected in either direction. The LED for the selected ASSIST RATIO will be illuminated. The Assist Ratio keys perform the same function in both AutoPilot™ and Operator mode.

<b>Assist Ratio Control Keys</b>	
<b>Selection</b>	<b>Description</b>
1:1	Initiates one inflation-deflation cycle for each cardiac cycle; generally used after timing has been optimized. Provides maximum IABP support.
1:2	Initiates one inflation-deflation cycle for every second cardiac cycle; generally used to initiate counterpulsation and optimize timing, and to wean patient from IABP support.
1:4	Initiates one inflation-deflation cycle for every fourth cardiac cycle; generally used to wean patient from IABP support.
1:8	Initiates one inflation-deflation cycle for every eighth cardiac cycle; generally used to wean patient from IABP support.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

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#### Balloon Volume

#### AutoPilot™ and Operator Modes:



The AutoCAT™2 SERIES automatically sets the volume from the IAB connector. However when volume changes are required the AutoCAT™2 Series allows the user to set the precise volume to be delivered to the IAB in 0.5 cc increments. Volume can be changed while the pump is OFF or during pumping. If IAB volume is changed while pumping, the pump will pause for 1 or 2 beats to reset the volume and then resume pumping at the new volume setting.

When the BALLOON VOLUME function key is pressed, the multi-function keys will change to the following:

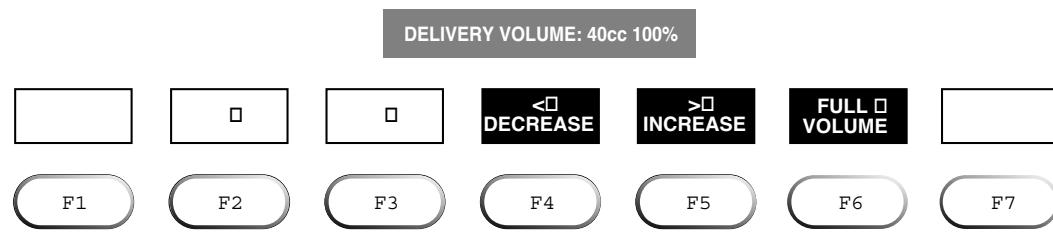


Figure 3.13: Initial display of volume change.

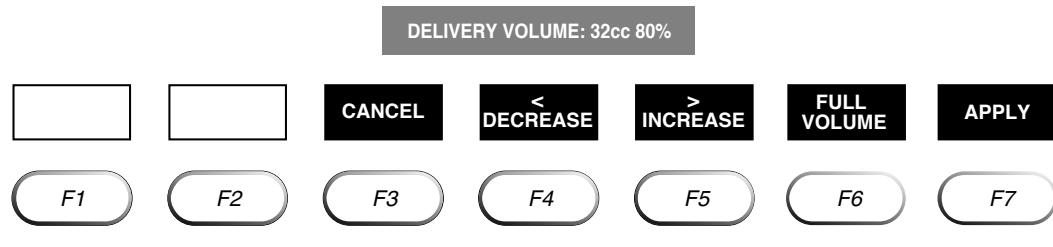


Figure 3.14: Example of IAB volume change to less than full volume.

**3. Principles of Operation**  
**3.3: Control Keys and Function Keys**

**CAUTION**

If IABP volume is changed while pumping patient support will be momentarily suspended as the volume is updated. Insure the patient will tolerate this procedure before pressing APPLY to initiate the volume change.

**Change Volume:**

1. Press BALLOON VOLUME key.
2. INCREASE or DECREASE the volume to the desired setting.
3. Press APPLY to change volume.

NOTE: Pump will reset volume in 1 or 2 beats and resume pumping.

4. If volume change was made in error, press CANCEL or wait 30 seconds for multifunction keys to time out.

**Return to Full Volume:**

1. Press BALLOON VOLUME key.
2. Press FULL VOLUME multifunction key.
3. Press APPLY to change volume.

NOTE: Pump will reset volume in 1 or 2 beats and resume pumping. If volume change was made in error, press CANCEL or wait 30 seconds for multifunction keys to time out.

NOTE: If the volume is changed from the current delivered volume and then returned to that volume, the CANCEL and APPLY keys will disappear. These keys are only available when changing the volume from the current delivered volume setting.

NOTE: If the pump is in Stand-by when the volume change is made, the pump will go to OFF when APPLY is pressed. Press pump ON to start pumping at the new volume setting.

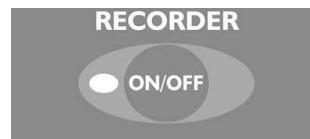
### **3. Principles of Operation**

#### **3.3: Control Keys and Function Keys**

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##### **Recorder Control Keys**

###### **AutoPilot™/Operator Mode:**



The AutoCAT™2 Series is equipped with an annotating strip chart recorder. You can start or stop a recording by pressing the Recorder ON/OFF key. Selection of recorded parameters is done by the use of the Recorder Setup in the multi-function key section.

<b>Recorder Setup Control Key Functions</b>	
<b>Control key</b>	<b>Description</b>
RECORDER ON/OFF	Turns recorder on/off.

## **Alarm System**

The ALARM control keys allow you to disable or enable AutoCAT™2 Series diagnostic alarms. Before describing the ALARM control keys further, the AutoCAT™2 Series diagnostic alarm system will be explained.

The AutoCAT™2 Series diagnostic alarm system continuously monitors operating conditions. The AutoCAT™2 Series is able to detect and alert you to conditions which require a response. When an alarm condition occurs, the AutoCAT™2 Series displays an alarm message, including suggested corrective actions. Press the ALARM RESET control key to reset the audio tone. Possible causes and corrective actions are listed in Chapter 8, Troubleshooting. (If the alarm is not reset automatically, ALARM RESET must be pressed prior to re-initiating pumping. If multiple alarms have been issued, the ALARM RESET key must be pressed once for each alarm present.)

The alarms are organized into four classes: Class 1, Automatic Response; Class 2, Automatic Response; Class 3, and Class 4 Information Only. The Class 1 (automatic response) alarms alert you to potentially serious conditions that require your immediate attention. Certain alarms have subcodes (System Error, Large Helium Leak, Possible Helium Loss, High Baseline, Unable to Refill and High Pressure). These subcodes will be displayed on the LCD as a number in brackets and on the recorder. These subcodes are used only for engineering purposes and are not significant in the clinical environment.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

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#### Alarm Control Keys - AutoPilot™ and Operator Modes



#### Alarm Control Keys - AutoPilot™ and Operator Modes

The ALARM RESET key allow you to reset the audio alarm tone.

The alarms ON/OFF key allows you to disable the pneumatic alarms (gas surveillance alarms) for a period of up to 60 minutes, or permanently if selected internally; and allow you to re-enable the alarm system when it is in the OFF mode. A symbol indicating that the alarms are off will be seen in the left corner of the display under the LEAD SELECT. The actual number of minutes remaining is also displayed. The alarms automatically resume when the number of minutes reaches 0 min. An ALARMS OFF message is continuously displayed on the top of the display above the ECG while the alarms are off.

The ALARMS OFF key disables all Class 1 alarms except SYSTEM ERROR. The alarms should be on during normal operation. You can also adjust the volume of the audio alarm tone. When ALARMS OFF is pressed the multi-function keys show the selections for the number of minutes for alarms to be disabled. Current selection is highlighted in reverse video.



Figure 3.15: ALARMS OFF time (minutes) selections

NOTE: PERMANENT OFF is available only if an internal switch is selected. To disable alarms permanently, press PERMANENT OFF again to confirm. Alarm messages are displayed when alarms are off.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

Alarm Control Keys	
Selection	Description
OFF	<p>Disables all Class 1 alarms except SYSTEM ERROR. Pressing the multi-function control key changes the disabled period by ten minutes, up to a maximum of 60 minutes (alarms are automatically restored after the disabled period has elapsed).</p> <p><b>Note: FLASHING LED ON ALARMS OFF CONTROL KEY INDICATES THAT THE ALARMS ARE DISABLED AND A SYMBOL SYMBOL WITH TIME REMAINING FOR ALARMS OFF AND A WARNING MESSAGE ARE DISPLAYED.</b></p>
[ON]	Restores normal alarm functions if alarms have been disabled.
RESET	Silences the audible alarm tone and clears the alarm message; if pumping was interrupted, the alarm message is not cleared until PUMP STNDBY or PUMP ON is pressed; if there is more than one alarm condition, one alarm message is cleared at a time. RESET must be pressed prior to reinitiating pumping for Class 1 alarms. Alarm ON and OFF and RESET keys perform the same in AutoPilot™ and Operator mode.

NOTE: Drain and refill tasks are suspended when alarms are off.

### **3. Principles of Operation**

#### **3.3: Control Keys and Function Keys**

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#### **Multiple Alarm Handling**

Multiple alarm conditions can occur. Alarm handling by the AutoCAT™2 Series is based on a unique priority code assigned to each alarm. The highest priority alarm which occurs is always displayed first.

When multiple alarms occur, these alarms are stacked in the order of priority. To view each alarm condition, press the RESET key. Each subsequent alarm will be displayed in priority order with troubleshooting information. Continue to RESET the alarms until all alarms are cleared. When all alarms are cleared the RESET LED will be off.

**NOTE:** Alarms are listed by Class from highest to lowest priority in the following tables.

#### **WARNING**

Alarms should be on at all times to insure safe operation. If alarms are suspended, the IABP should be continuously monitored by trained personnel. A warning message “ALARMS OFF” will be continuously displayed above the ECG trace when alarms are off.

#### **AutoCAT™2 Series: Pump Actions During Alarm**

***The Class 1 alarms will cause the AutoCAT™ 2 series to:***

- stop pumping (Pump OFF key will illuminate)
- deflate the IAB
- open the vent valve
- initiate an audio alarm
- display an alarm message
- freeze the waveform display
- print approximately the last seven seconds of the balloon and AP waveforms on the strip chart recorder

***The Class 2 alarms will cause the AutoCAT™ 2 series to:***

- stop pumping (Stand-by mode)
- deflate the IAB
- open the vent valve
- initiate an audio alarm
- display an alarm message

***The Class 3 alarms will cause the AutoCAT™ 2 series to:***

- initiate an audio alarm
- display an alarm message

***The Class 4 alerts will cause the AutoCAT™ 2 series to:***

- display an alarm message

**3. Principles of Operation**  
**3.3: Control Keys and Function Keys**

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<b>ALARM MESSAGES (Class I)</b>	
Alarm Message	Description
<b>System Error</b>	The AutoCAT™ 2 Series computer circuitry or hardware has malfunctioned.
<b>Unable to Refill</b> 1. Helium supply low 2. Check timing settings 3. Leak in tubing and connections 4. Fill valve malfunctioning	The AutoCAT™ 2 Series cannot refill the IAB to 2.5 mmHg. The alarm is issued 30 seconds after the baseline drop is detected in all trigger modes except AFIB. When AFIB trigger is selected the alarm is issued 60 seconds after the baseline drop is detected.
<b>Possible Helium Loss 2</b> 1. Leak in tubing and connections 2. Blood in catheter tubing 3. Kinked Catheter 4. Ectopic beats	The AutoCAT™ 2 Series calls for 3 refills within 2 minutes.
<b>Possible Helium Loss 3</b> 5. Leak in tubing and connections 6. Blood in catheter tubing 7. Kinked Catheter 8. Ectopic beats	The BPW baseline falls below -10 mmHg for 3 consecutive beats.
<b>High Pressure</b> 1. Kinked Catheter 2. Partially wrapped balloon 3. Balloon too large	The BPW plateau pressure is above 250 mmHg for 5 consecutive beats or 10 of the last 20 beats.
<b>High Baseline</b> 1. Kinked Catheter 2. Partially wrapped balloon 3. Improper balloon position	The pressure in the balloon exceeds 25 mmHg during deflation.
<b>Large Helium Leak</b> 1. Check balloon/tubing connections 2. Blood in catheter 3. Possible internal balloon leak 4. Check vent hole	The BPW pressure is less than 5 mmHg during inflation.
<b>Purge Failure</b> 1. Check tubing connections 2. Helium supply low or off 3. Loss of trigger 4. Possible valve malfunction	The AutoCAT™ 2 Series cannot fill to 2.5 mmHg.

### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

ALARM MESSAGES (Class II)	
Alarm Message	
<b>Standby Alarm Disabled</b> To re-enable STANDBY alarm, press <b>Alarm Reset</b> <b>PUMP On:</b> Resume pumping <b>PUMP OFF:</b> Stop pumping	3 minute Standby alarm suspended indefinitely.
<b>Standby longer than 3 MIN</b> <b>PUMP ON:</b> Resume pumping <b>RESET:</b> Continue Standby <b>STANDBY, STANDBY:</b> Disable standby Alarm indefinitely	Pump has been in standby for three minutes.
<b>ECG Trigger loss</b>	Eight seconds elapsed without a recognizable trigger point in the ECG waveform (occurs only in PATTERN, PEAK, A FIB, V PACER and A PACER trigger modes). NOTE: ECG Trigger Loss Alarm is extended to 30 seconds when alarms are off.
<b>Pressure Trigger loss</b>	Eight seconds elapsed without a recognizable trigger point in the AP waveform (occurs only in ART PRESS trigger mode). NOTE: Pressure Triggering Loss Alarm is extended to 30 seconds when alarms are off.
<b>ECG Lead Fault detected</b>	The ACAT™ I detects high electrical impedance in the ECG leads (usually caused by loose or broken patient leads). NOTE: The ECG lead which has the fault is shown in the alarm message.
<b>Trigger Loss</b> 1. ECG/AP/Pacer signals not found 2. Check Patient 3. Check ECG/AP connections	AutoPilot™ mode only No trigger can be established. Check patient condition.

**3. Principles of Operation**  
**3.3: Control Keys and Function Keys**

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<b>ALARM MESSAGES (Class III)</b>	
<b>Alarm Message</b>	<b>Description</b>
<b>AP FOS Signal Weak</b> 1. Check FOS connection 2. Use alternate AP source 3. Clean/service FOS connector 4. Call field service	AutoCAT™2 WAVE only Light source from AP LightWAVE™ is low. This may indicate a problem in the LightWAVE™ sensor, the LightWAVE™ electronics or the connection point. Check these components. Disconnect and reconnect the sensor. Make sure a click is heard.
<b>AP FOS Sensor Out of Range</b> 1. AP accuracy may be affected 2. Use alternate AP source 3. Call field service	AutoCAT™2 WAVE only Electrical signal for AP LightWAVE™ cannot be detected. Switch to an alternate AP source
<b>AP FOS Cal key missing or Corrupt</b> 1. Connect AP FOS Cal key 2. Replace IAB catheter 3. Call Field Service	AutoCAT™2 WAVE only LightWAVE™ Cal key is disconnected or data has been lost. Switch to an alternate AP source. Change IAB catheter as LightWAVE™ is needed.
<b>Drain Failure</b> Excessive water build-up; Repeat purge cycle Possible drain valve failure	Cannot remove condensate
<b>Deflation Timing beyond 100%</b>	Operator mode only Check for proper timing
<b>Timing Error</b> Insufficient time to Deflate Check Trigger mode Select Operator mode Change trigger/timing settings	Inflation and deflation points need to be adjusted (insufficient time to deflate the balloon before the next inflation cycle).
<b>Warning: Battery Inoperative</b> Call Field Service	The AutoCAT™2 will not run in battery mode due to a faulty DC circuit breaker.
<b>Available Battery Power</b> Less than 5 minutes	Less than 5 minutes of battery power remain before system battery operation shuts down.
<b>Available Battery Power</b> Less than 10 minutes	Less than 10 minutes of battery power remain before system battery operation shuts down.
<b>Available Battery Power</b> Less than 20 minutes	Less than 20 minutes of battery power remain before system battery operation shuts down.
<b>System Running on Battery Power</b>	AC power was intentionally or accidentally disconnected and the AutoCAT™2 has automatically switched to battery power.
<b>Valid ECG Trigger Detected</b>	Operator mode only Internal trigger selected and ECG signal is available. Check patient condition and select an ECG trigger mode.

### **3. Principles of Operation**

#### **3.3: Control Keys and Function Keys**

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<b>ALARM MESSAGES (Class III) – Continued</b>	
<b>Alarm Message</b>	<b>Description</b>
<b>Weaning Step Complete</b> Evaluate Hemodynamics, set Parameters, press START WEANING To initiate next step.	Weaning Timer Expired
<b>Arterial Pressure Alarm</b> AP has fallen below set limit: 1. Check AP for disconnect 2. Assess patient hemodynamics 3. Change AP alarm limit	AP has fallen below set limit
<b>Low Helium Tank Pressure</b>	Helium tank pressure < 100 psi

**3. Principles of Operation**  
**3.3: Control Keys and Function Keys**

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<b>ALARM MESSAGES (Class IV)</b>	
<b>Alarm Message</b>	<b>Description</b>
<b>Possible Late Deflation</b> 1. Check deflation timing 2. Check BPW 3. Turn Arrhythmia timing OFF 4. Select Operator mode	AutoPilot™ mode only The patient has a short electro-mechanical delay or a slow IAB and R wave deflation is being used. Check deflation timing.
<b>Erratic Triggering</b> 1. Check Trigger mode 2. Check ECG/AP signals 3. Select alternate ECG/AP signal 4. Select Operator mode	AutoPilot™ mode only ECG trigger is erratic due to noise or patient movement. Trigger is switching between Pacer and AP trigger more than 3 times in 1 minute.
<b>No ECG signal available</b> 1. Check ECG connections 2. Check ECG leads 3. Change ECG cable	AutoPilot™ mode only ECG signal lost, pump has switched to AP or Pacer trigger. Check ECG connections.
<b>No AP signal available</b> 1. Check AP connections 2. Check AP transducer 3. Change AP transducer	AutoPilot™ mode only AP signal has been lost. Pump is using ECG or Pacer signal for triggering. Check AP connections.
<b>ECG Lead Fault</b> 1. Check electrode contact 2. Check ECG connections 3. Replace ECG cable 4. Connect ECG Cable	AutoPilot™ mode only ECG electrode is off or loose. An alternate ECG lead has been selected.
<b>Arrhythmia Timing Not available</b> 1. Check Trigger mode 2. Check Timing 3. Select Operator mode	AutoPilot™ mode only An arrhythmia has been detected but the arrhythmia timing key is OFF.
<b>Warning:</b> Dead Clock Battery Call Field Service	Computer battery has no power.
<b>Warning:</b> Low battery for static RAM Call Field Service	RAM battery has no power.

### **3. Principles of Operation**

#### **3.3: Control Keys and Function Keys**

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#### **Cursor - AutoPilot™ and Operator Modes**



The AutoCAT™2 Series has a horizontal cursor. This cursor will allow specific measurements of the Arterial Pressure Waveform or of the Balloon Pressure Waveform.

The cursor may be moved by pressing the  $\wedge$  or  $\vee$  arrow key in the cursor section. The cursor moves in 2 or 3mmHg increments. The numerical value located at the point where the cursor intersects the waveform is seen at the right hand side of the waveform area for which the cursor is being used, on the cursor line.

The cursor may also be used when the waveform display is frozen. To freeze waveforms, press DISPLAY FREEZE and then use the cursor as described. The cursor performs the same in both the AutoPilot™ and Operator mode.

## Help - AutoPilot™ and Operator Modes



The AutoCAT™2 Series IABP system has HELP incorporated for many of the pump functions. HELP is accessed via the HELP key on the Right side of the keypad. All HELP screens are displayed in the lower Right side of the LCD in WHITE text.

There are two kinds of HELP messages, general or setup HELP and key-specific HELP which may be used with a single function or multifunction key.

Most keys on the AutoCAT™2 Series will have key specific HELP text. Key specific HELP will be displayed when the user touches the HELP key and then touches the desired key within 10 seconds. . HELP messages are specific to the operation mode selected. HELP messages for start-up will detail the steps needed for the selected operation mode only.

If HELP is pressed, Initial Setup HELP will be displayed or the message:

PRESS DESIRED KEY FOR HELP MESSAGE  
OR PRESS HELP AGAIN TO CANCEL REQUEST

### *HELP Operations summary:*

INITIAL SETUP: Touch HELP

KEY SPECIFIC HELP: Touch HELP then DESIRED KEY

MULTIFUNCTION HELP: Touch HOME, then HELP, then DESIRED KEY

To cancel HELP touch the HELP key while the message above is displayed. All HELP text and messages will be cleared from the display. NOTE: When HELP is activated BEFORE a key press, ONLY the HELP message will be displayed. The function of the key pressed will NOT be activated until the subsequent press of the same key that HELP is describing or on the press of any other key.

### **Help Key Operations and Text**

See Appendix H for a summary of the HELP text which will be displayed with different key combinations. This table shows the keys presses and HELP message which will be displayed for that key.

### **3. Principles of Operation**

#### **3.3: Control Keys and Function Keys**

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#### **Display Control - AutoPilot™ and Operator Modes**



The DISPLAY FREEZE control key allows you to freeze approximately seven seconds of waveforms on the LCD. This feature is used for examining waveforms for adequate triggering, timing, and balloon pressure. Hemodynamic data continues to be updated. Display Control works the same in AutoPilot™ and Operator mode.

<b>Display Control Key</b>	
<b>Selection</b>	<b>Description</b>
FREEZE	Freezes the waveform display; the moving waveform display returns when the FREEZE key is pressed a second time.

## **Home - AutoPilot™ and Operator Modes**



Pressing the HOME key will display multi-function keys for operations not found on the control module. These include:

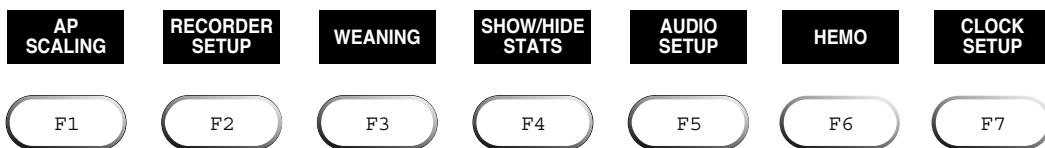
- Recorder Setup
- Weaning Control
- Show Stats
- Audio Volume Control
- Hemodynamic Calculations
- Clock Setup

Pressing HOME when these functions are shown will clear the display. HOME works the same in AutoPilot™ and Operator modes.

## **Multi-Function Keys**

Below the LCD are located seven (7) multi-function keys. The operation which each performs is indicated directly above the key on the LCD. The active selection(s) are highlighted by reverse video. The multi-function keys may be accessed by pressing HOME or any multi-function key when no display is present.

In the normal operation mode the following functions will be displayed:



### 3. Principles of Operation

#### 3.3: Control Keys and Function Keys

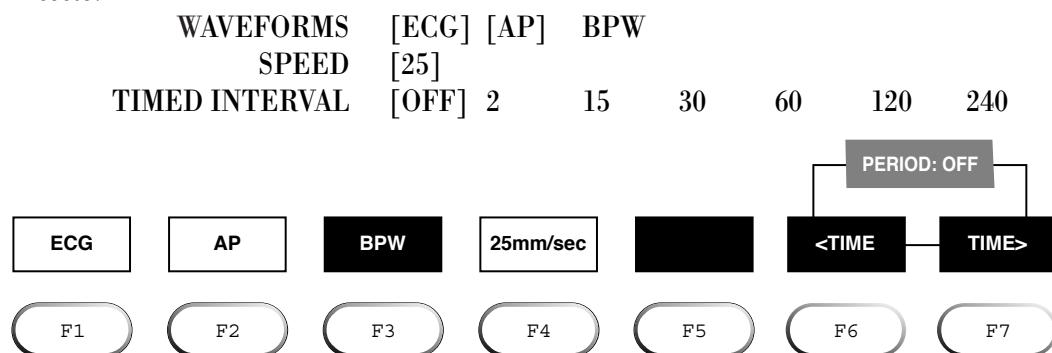
#### Recorder Setup

RECORDER  
SETUP

F2

Selects waveforms to be recorded. Sweep speed and time interval for automatic recordings.

Presets:



Recorder Scaling - AP Waveform		
Selection	Description	
AP	0-100	(25.0mmHg /div dual trace, 12.5mmHg /div single trace)
DISPLAY	25-100	(18.75mmHg /div dual trace, 9.375mmHg /div single trace)
	*25-125	(25mmHg /div dual trace, 12.5mmHg /div single trace)
SCALE	0-150	(37.5mmHg /div dual trace, 18.75mmHg /div single trace)
	[50-150]	(25.0mmHg /div dual trace, 12.5mmHg /div single trace)
	50-200	(37.5mmHg /div dual trace, 18.75mmHg /div single trace)
	0-200	(50.0mmHg /div dual trace, 25.0mmHg /div single trace)
	*0-250	(31.25mmHg /div dual trace, 15.625mmHg /div single trace)
	50-250	(50.0mmHg /div dual trace, 25.0mmHg /div single trace)

\* Available in Autoscaling mode only.

### 3. Principles of Operation

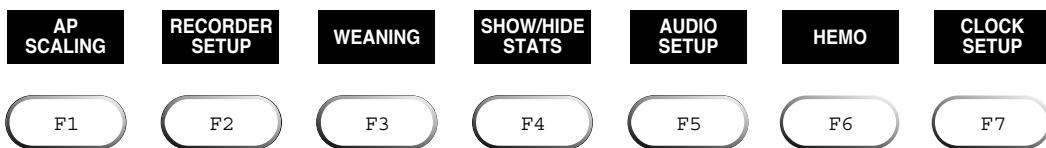
#### 3.4: Balloon Inflation and Deflation Controls

#### Weaning Setup

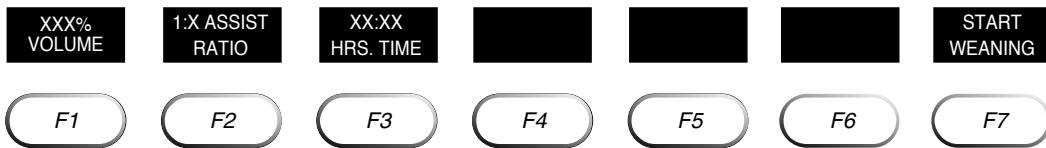


In addition to the use of the Assist Ratio and Balloon Volume keys on the AutoCAT™2 Series keypad to select the desired weaning parameters, the AutoCAT™2 Series has the function to select and change these parameters and set a time for these reduced settings. At the end of the selected time period, the user will be alerted to check the patient hemodynamic status and continue weaning or resume full IABP support.

To implement Weaning with the timer, Press HOME and WEANING SETUP. The following options will appear:



Press the parameter key, which you want to change, note it will become highlighted. Press the same key again and the following keys will appear:



#### START WEANING

When all settings are made, press START WEANING. When the START WEANING key is pressed, the pump will implement the new assist ratio and volume settings. This will cause the pump to pause for 1 or 2 beats to make these adjustments. When weaning is started the following keys will appear and a warning message "WEANING" will be displayed in the multi-function area of the LCD.

The timer will indicate the time remaining for these weaning settings. The seventh multifunction key will change from START WEANING to 100% VOL @ 1:1. This key is used to stop weaning and immediately return to full support at 100% IAB volume based on the IAB connector at 1:1 assist ratio. The timer and the Full Support key will remain in the multifunction key area whenever the weaning mode is in use.

### **3. Principles of Operation**

#### **3.4: Balloon Inflation and Deflation Controls**

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#### **STOP WEANING**

Weaning can be suspended or terminated in several ways.

1. **100% VOL. @ 1:1 Key:** This key will immediately stop weaning and resume full support at 100% Volume and 1:1 assist.
2. **Changing assist ratio:** If the assist ratio is changed while weaning is in use, the weaning program will be suspended. All previous weaning settings will be retained for future use.
3. **Changing IAB volume:** If the IAB volume is changed while weaning is in use the weaning program will be suspended. All previous weaning settings will be retained for future use.

#### **WEANING STEP COMPLETE:**

When the timer expires for a weaning step, a Class 3 alert will be displayed:

**WEANING STEP COMPLETE EVALUATE HEMODYNAMICS AND CONTINUE WEANING OR RESUME FULL IABP SUPPORT**

Current IAB volume and assist ratio from the weaning setup will be used for pumping until another weaning setup is selected or until pumping is discontinued.

#### **WEANING AND INTERNAL TRIGGER MODE**

Weaning cannot be set when INTERNAL trigger mode is selected. The user must change to another trigger mode if the weaning mode is required. If you are in weaning and the INTERNAL trigger mode is selected and confirmed by pressing the INTERNAL key twice, weaning will be suspended and the INTERNAL mode will be selected.

**NOTE:** IAB volume cannot be reduced more than 50% of the IAB connector volume in the weaning setup. Generally, IAB volume should not be reduced more than 30% of the full volume.

### Show/Hide Stats

**SHOW/HIDE  
STATS**

F4

This key will display a summary of all current pump operational settings as well as selected information which is tracked by the AutoCAT™2 Series. SHOW STATS when pressed will display parameters below in the HELP message area. The multi-function key label will then change to HIDE STATS. This display will stay on screen for 30 seconds or until HIDE STATS is pressed or until HOME is pressed.

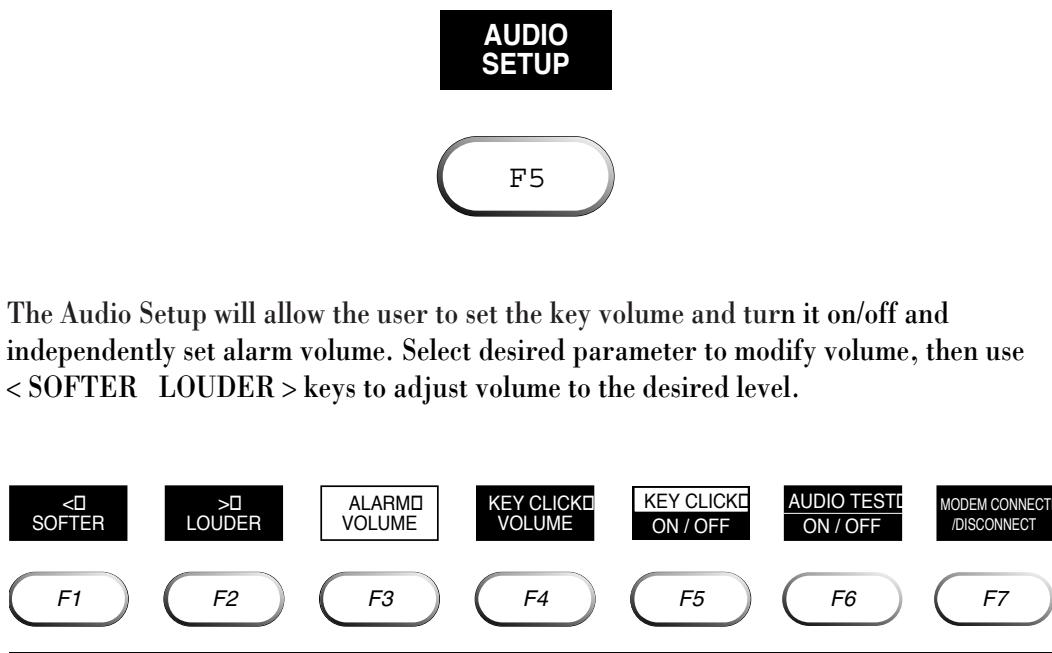
Stats displayed:

DAY-TIME	____/____/____:____	Displays current setting of date and time.
POWER STATUS	____ Volts	Displays battery voltage and if the AutoCAT™2 Series is charging the battery, running on battery power, or checking power source.
ALARMS	____	Displays the most recent alarm code and subcode (if any) that was issued.
RECORDER	____ mm/sec.	Shows current recorder settings for Trace 1 and Trace 2 as well as sweep speed.
ASSIST RATIO	1:1	
HELIUM TANK	____ psi	
FOS STATUS	____	

### 3. Principles of Operation

#### 3.4: Balloon Inflation and Deflation Controls

#### Audio Setup



#### Options available for Audio Setup

- <SOFTER/LOUDER> Changes volume of alarms/key clicks in desired direction.
- ALARMS VOLUME Selects alarm volume for adjustment.
- KEY CLICK VOLUME Selects key click volume independently of alarms for adjustment.
- KEY CLICK ON/OFF Turns key click sound on/off.
- AUDIO TEST ON/OFF Initiates audio test to check speaker and audio controls for alarm tone.

#### Presets

Alarm Volume	ON	80%
Key Click	ON	20%
Audiotest	OFF	

**NOTE:** If a direct connection between the AutoCAT™2 Series and computer is made, the modem connect key must be pressed to initiate the connection. If the disconnect key is pressed, the AutoCAT™2 Series will stop sending data to the computer. (This key is not used when a phone connection to the AutoCAT™2 Series is made.)

## Hemodynamic Calculations (Hemo Cales)



In order to make the hemodynamics more stable for charting, a new function has been added to the HEMODYNAMICS multifunction key. When HOME and HEMODYNAMICS are pressed, the calculations will appear as described in the operator's manual AND the numeric values will freeze on the display for 30 seconds. The HEMODYNAMICS key will be highlighted in WHITE when the AP values on the display are frozen.

NOTE: The IABP must be pumping in order for AP values to be frozen and calculations to be performed. If the pump is in OFF or STANDBY, the user will be prompted to press pump ON to calculate and freeze the AP values.

If the HEMODYNAMICS key is pressed while the numeric values are frozen, the values will begin updating on a beat to beat basis. If the assist ratio is changed while the AP values are frozen, the values will begin updating on a beat to beat basis. The following message will appear in the key prompt area:

"ASSIST RATIO HAS CHANGED, PRESS HEMO KEY AGAIN TO FREEZE AP VALUES"

When 30 seconds has expired, the pump will resume updating the hemodynamics on a beat to beat basis. If the pump is OFF and HEMODYNAMICS is pressed, the following message will appear:

"PRESS PUMP ON, THEN HEMO KEY TO CALCULATE AND FREEZE AP VALUES"

### CAUTION

The frozen hemodynamics may not represent the actual patient condition if there is wide variation in the heart rate and rhythm. The user should verify that these values reflect the actual hemodynamic condition prior to using them as the basis of treatment decisions.

### CAUTION

The user should continue to monitor the displayed waveforms on the LCD, since these reflect the current condition of the patient and may show a significant change in patient condition which warrants clinical intervention.

This is a function which will automatically calculate the following pressure differences from the AP Waveform on the last assisted beat.

- 1 AUG-SYS
- 2 AUG-DIA

To obtain these calculations press the Hemo Calc key. The calculations will be displayed in the HELP area.

### **3. Principles of Operation**

#### **3.4: Balloon Inflation and Deflation Controls**

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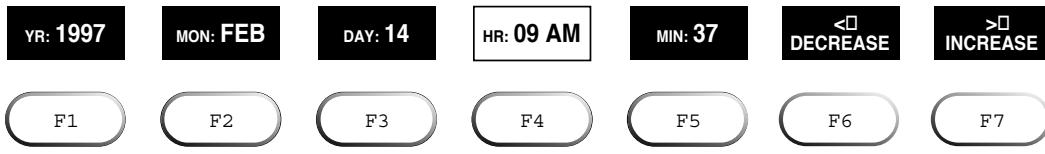
#### **Clock Setup**

**CLOCK  
SETUP**

**F7**

Clock Setup allows the user to set the time and date for the pump. It is important that the clock be correctly set for accurate recording time.

To set time, press the multi-function key under the desired parameter. The parameter will be highlighted. Move the time backward (F6) or forward (F7) as desired. Continue this same process for other parameters that require changes.





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### CHAPTER 4: Troubleshooting

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#### System Diagnostics

The AutoCAT™2's diagnostic alarm system continuously monitors operating conditions. The AutoCAT™2 is able to detect and alert you to many conditions that require a response. When an alarm condition occurs, the AutoCAT™2 displays a message, including suggested corrective actions. Press the ALARM RESET control key to reset the audio tone. Possible causes and corrective actions are listed at the end of this chapter. ALARM RESET must be pressed prior to re-initiating pumping. If multiple alarms have been issued, the ALARM RESET key must be pressed once for each alarm present.

The contents of this chapter include:

#### CHAPTER 4: Troubleshooting 4-1

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The AutoCAT™2 is designed to the highest standards of reliability. However, specific patient states, operating conditions or pump malfunctions can cause shut down of pumping action. Pump shut down requires immediate staff action. The pneumatic control system automatically vents, deflating the balloon to a hemodynamically safe level. However, allowing the balloon to remain in place while deflated in excess of 30 minutes is hazardous. Blood can become trapped in the folds of the deflated balloon material and thrombus formation may occur. To aid the staff in identifying the cause of a shutdown, thereby reducing pump down-time, the AutoCAT™2 has computerized diagnostics. The display will automatically display pre-programmed alphanumeric messages that identify the problem and suggest procedural steps for immediate correction. When a shutdown occurs, the time should be noted; hospital personnel knowledgeable in the maintenance of this equipment should immediately be called. If repair and pumping cannot be accomplished within 30 minutes, or another console is not available for use, balloon removal should be accomplished as soon as possible. To further reduce the danger of thrombus formation, a 50/60 cc syringe should be connected to the balloon catheter and inflate and deflate the balloon rapidly with air several times every 10 minutes. This procedure will aid in preventing the formation of thrombus but should be used only as an emergency procedure for short periods of time while awaiting the physician's arrival. It is strongly recommended that each hospital have more than one IABP available, so that a backup pump can be substituted in the event of a major pump shutdown. The following text describes the diagnostic messages, their cause of occurrence and steps to be taken to correct the shutdown. The AutoCAT™2 IABP operator's manual further elaborates system diagnostics.

### **Alarm Detection and Classification**

The AutoCAT™2 detects more than 40 alarm conditions, which are grouped in 4 alarm classifications. Each alarm is classified in order of its priority and each alarm, based on its classification, will result in specific consequences when it occurs. In other words, some alarms cause the pump to default to pump STOP; some cause the pump to default to PUMP STANDBY and some simply display a message.

## 4. Troubleshooting

### 4.1: Alarm Classification

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#### ALARMS (in order of priority, grouped according to classification)

##### **Class 1: Causes Pump STOP**

- 1. System Error
- \*2. Unable to Refill
- \*3. Possible Helium Leak
- \*4. High Pressure
- \*5. High Baseline
- \*6. Large Helium Leak
- \*7. Purge Failure

##### **Class 2: Causes Pump STANDBY**

- 8. Standby Alarm Disabled
- 9. Standby longer than 3 minutes
- 10. ECG Fault Lead Detected
- \*\*11. ECG Trigger Loss
- \*\*12. Pressure Trigger Loss
- 13. Trigger Loss

##### **Class 3: Causes Audio ALARM and Visual Message Display**

- 14. AP FOS Signal weak  
(AutoCAT™2 WAVE only)
- 15. AP FOS CAL Key missing or corrupt  
(AutoCAT™2 WAVE only)
- 16. AP FOS Sensor Out of Range  
(AutoCAT™2 WAVE only)
- 17. Drain Failure
- 18. Deflation 100%
- 19. Timing Error
- 20. Battery Inoperative
- 21. Battery life less than 5 minutes
- 22. Battery life less than 10 minutes
- 23. Battery life less than 20 minutes
- 24. System Running on Battery Power
- 25. ECG Detected during Internal Trigger
- 26. Weaning Step Complete
- 27. Arterial Pressure Alarm
- 28. Low Helium Supply

##### **Class 4: Visual Message Only**

- 29. Possible Late Deflation
- 30. Erratic Triggering
- 31. ECG Lead Fault
- 32. No ECG Signal Available
- 33. No AP Signal Available
- 34. Arrhythmia Timing Not Available
- 35. Warning: Dead Clock Battery
- 36. Warning: Low Battery for Static Alarm

#### ALARM AUDIO TONES

Each alarm classification has its own distinct audio tone.

Class 1: ALARM - Highest pitch audio tone with rapid interrupted beeps.

Class 2: ALARM - Lower pitch audio tone with slower interrupted beeps.

Class 3: ALARM - Lowest pitch audio tone with slowest interrupted beeps.

Class 4: No audio tone

\* ALARMS OFF disables these alarms only.

\*\* When the alarms are off, the time required to initiate these alarms is extended from 8 seconds to 30 seconds.

## Alarm Control Keys

### *ALARMS ON*

Pressing the ALARMS ON/OFF key will turn on all of the alarms if they had previously been turned off.

### *ALARMS OFF*

The AutoCAT™2 offers the operator the ability to disable certain alarms for a period of time. To disable the alarms, press the alarm ALARMS ON/OFF key. A menu will be displayed along the bottom of the LCD allowing the operator to select the amount of time for the alarms to be off. Once a selection is made, the alarms will be disabled for that period of time. The LED on the ALARMS ON/OFF key will flash when the alarms are off. Also, a  symbol will be displayed on the LCD, along with a counter showing the time remaining in the alarms off mode.

In the standard configuration, the maximum amount of time that can be selected for the alarms to be off is 60 minutes. However, if option switch #3 on the CPU PCB is ON, the ability to permanently disable the alarms is enabled.

### *ALARM RESET*

Activation of the ALARM RESET key will cause the AutoCAT™2 to silence the alarm audio tone. After the operator has corrected the cause of the alarm condition, balloon pumping can resume.

NOTE: (The alarm message will remain until pumping is resumed).

### *AUDIO LEVEL*

Allows volume changes in 10% increments for the alarm keys.

## **4. Troubleshooting**

### **4.1: Alarm Classification**

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The Class 1 alarms which are described in the following section, will cause the system to react in the following manner:

- Lights the Alarm Reset LED
- Freezes the LCD
- Stops the Pump and goes to the pump off mode
- Deflates the Balloon
- Opens the Vent Valve.
- Sounds an Audible Tone.
- Displays a Diagnostic Message

Prints approximately the last ten (10) seconds of the Arterial Pressure and Balloon Pressure waveform, patient hemodynamic data and the alarm condition.

### **CLASS 1 ALARM CRITERIA**

#### **1. System Error**

System Error alarms have been divided into eight (8) categories with additional sub alarms. These sub alarms will not be obvious to the user. The alarm identification will appear on the recorder strip and will be used as a diagnostic aid for the service engineer or an authorized representative. Sub alarms or codes will appear only on the display.

#### **SYSTEM ERROR 1**

Balloon Pressure greater than 50 mmHg for longer than 1.8 seconds.

#### **SYSTEM ERROR 3**

Pump controller failure.

Subcodes:

1. Bellows cannot move away from HOME position.
2. Bellows cannot move to HOME position.
3. At start of inflation stroke bellows is at HOME position.
4. Stepper stroke failed to complete in 500 milliseconds.
5. CPU-PUMP serial communication failure.

#### **SYSTEM ERROR 4**

Main CPU failure

Subcodes:

10. Bus error.
11. Spurious interrupt.
12. Address error.
13. Illegal instruction.
14. Zero division.

15. Real time clock watchdog.

16. Trace trap.

## SYSTEM ERROR 6

Front End failure.

All fault (subcodes) indicates consecutive fault detection for 5 seconds.

Subcodes:

1. FEB data packet rates out of range more than 2%.
2. FEB RAM failure.
3. FEB ROM failure.
4. FEB program logic fault.
5. FEB->CPU data packet out of sequence.

## SYSTEM ERROR 7

Keyboard Controller failure.

Subcodes:

1. Keyboard controller fails to startup.
2. Keyboard controller not responding to CPU command.
3. Keyboard controller fails to reset.
4. Invalid key code received.
5. Bad keyboard data packet received.
6. CPU->FEB command packet out of sequence.
7. CPU-FEB serial communication failure.
8. Received FEB data packet rate is far lower than normal, suspected fatal CPU program failure.
9. FEB ADC 12V reference out of range 2 seconds in a row.
- 10 or >. Stuck key detected. A key is considered stuck when its key dome is continuously closed for longer than specific limits. If the key is a single action key this limit is 30 seconds, if the key is a repeat action key this limit is 60 seconds.

## SYSTEM ERROR 8 (AutoCAT™2 Wave units only)

FOS board failure

Subcodes:

1. FEB hasn't received any FOS data packet for some time.
2. Received Instrument error message from FOS.

## **4. Troubleshooting**

### **4.1: Alarm Classification**

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3. Received FOS RS232 error message from FOS.

4. Received ongoing self test message from FOS.

#### **UNABLE TO REFILL**

Failure to fill helium to target level of 2.5 mmHg (usually after a drain task).

Subcodes:

1. Fill rate is extremely slow.

2. Cannot fill to target for 30 seconds since refill started, in any triggering mode except AFIB. Cannot fill to target for 60 seconds since refill started, in AFIB triggering mode. **POSSIBLE HELIUM LOSS**

#### **POSSIBLE HELIUM LOSS**

System requests a third refill within two minutes of the last refill.

#### **POSSIBLE HELIUM LOSS (3)**

Balloon Pressure baseline before inflation is below -10mmHg for two consecutive beats.

Possible causes for both large helium leaks and possible helium loss are leaks in the tubing, balloon connections, catheter, vent hole or balloon. Check all connecting points along the catheter and tygon tubing down to the insertion point for any leaks. If all connections appear tight and no leak is apparent, a leak test can be performed.

#### **Leak Test**

1. Press the RESET control key in the ALARMS field to silence any audible alarms.
2. Press the ALARMS OFF control key twice and then select the amount of time for the alarm to be off.
3. Use a pair of rubber-shod hemostats or other clamping device to clamp the catheter tubing between the quick connect valve and the bifurcation.
4. Press the ON control key to start pumping.
5. Observe the balloon pressure waveform. If the baseline falls, the leak is probably between the pump and the clamp. If the baseline does not fall, the leak is probably on the patient side: consider stopping the pump, removing the balloon catheter and inserting another catheter.
6. Press the PUMP OFF control key and remove the hemostat.
7. Check the O-rings on the balloon connector, wipe off any debris and make sure that the connection at the quick connect valve is tight.

Also, examine the tubing at the balloon connector and at the catheter junction. If the tubing appears to be stretched in either location, see the instructions below to repair the tubing.

8. Repeat steps 2-4. If the baseline remains steady, the leak has been corrected and you can resume pumping. If the baseline continues to fall, the leak is in the control system or the connector. Complete steps 9-10.

9. Press the PUMP OFF control key and remove the hemostat.
10. Remove the balloon connector, cut off 1/2" of tubing, replace the connector and repeat steps 2-4. If the baseline remains steady, the leak has been corrected and you can resume pumping. If the baseline continues to fall, there may be an internal console leak. Call Arrow International for service.
11. If the alarms are still disabled, press the ON control key to re-enable the alarms.
12. Press ALARM RESET to remove alarm messages.

#### **Tubing Repairs**

1. To repair a tubing leak, wrap non-porous tape (e.g., electrical tape) around the tubing at the site of the leak.
2. To repair stretched tubing at the balloon connector, remove the compression ring and pull the connector off the tubing. Then cut off a 1/2 inch segment from the end of the tubing and reconnect the balloon connector and the compression ring.
3. To repair stretched tubing at the catheter junction, disconnect the tubing from the junction. Then cut a 1/2 inch segment from the end of the tubing and reassemble the junction.

If the leak is found at the QUICK CONNECT, Op-Site® or other occlusive, clear dressing material may be used to repair the leak.

#### **HIGH PRESSURE**

Balloon Pressure plateau pressure exceeds 250 mmHg, either for 5 consecutive beats, or for at 10 beats in the most recent 20 beats.

Subcodes:

1. Condition occurred in non-AFIB triggering mode.
1. Condition occurred in AFIB triggering mode.

#### **HIGH BASELINE**

Balloon Pressure baseline prior to inflation is higher than 25 mmHg.

Subcodes:

1. Condition occurred in triggering mode other than AFIB and inflation timing is less than 100%.
2. Condition occurred in triggering mode other than AFIB and inflation timing is at least 100%.
3. Condition occurred in AFIB triggering mode.

## **4. Troubleshooting**

### **4.1: Alarm Classification**

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#### **LARGE HELIUM LEAK**

A large helium leak is detected.

Subcodes:

1. Balloon Pressure plateau is less than 5mmHg.
2. Balloon Pressure plateau is less than 1/8th of BP peak 5 beats ago.
4. Balloon Pressure peak for current beat is < half of peak 5 beats ago.

Subcodes are additive, for example, if causes for both subcodes 1 and 2 are detected the subcode will be 3.

#### **PURGE FAILURE**

System fails to complete the initial purge cycle within 8 seconds.

The Class 2 alarms which are described in the following section will cause the system to react by:

- Stopping the pump and going to the pump standby mode.
- Deflating the balloon.
- Leaving the vent valve closed.
- Sounding an audible tone.
- Displaying a diagnostic message.

### **CLASS 2 ALARM CRITERIA**

#### **STANDBY ALARM DISABLED**

STANDBY alarm has been disabled by the user.

#### **STANDBY LONGER THAN 3 MIN**

System has been in STANDBY status for longer than 3 minutes.

#### **ECG LEAD FAULT (Lead)**

In OPERATOR MODE: ECG skin lead (s), or ECG lead cable trunk, or ECG cable Nicolay connector disconnected, or 3-lead cable is connected or cable is defective.

#### **ECG TRIGGER LOSS**

In OPERATOR MODE: While pumping in an ECG trigger mode, relevant trigger was not detected for 8 seconds if alarms are enabled, or 30 seconds if alarms are disabled.

#### **PRESSURE TRIGGER LOSS**

In OPERATOR MODE: While pumping in AP triggering mode, AP trigger was not detected for 8 seconds if alarms are enabled, or 30 seconds if alarms are disabled.

#### **TRIGGER LOSS**

In AUTOPILOT™ MODE: Can't find any ECG, AP or PACER trigger, on any of the ECG or AP signal sources.

The Class 3 Alarms which are described in the following section will cause the system to react by:

- Sounding an Audible Tone.
- Displaying a Diagnostic Message.

NOTE: Pumping is not stopped but action is required.

### **CLASS 3 ALARM CRITERIA**

#### **AP FOS SIGNAL WEAK** (AutoCAT™2 Wave units only)

FOS catheter is not connected to the pump, or the light received from sensor is low due to a bad sensor, broken (kinked) fiber optic line or dirty connector.

#### **AP FOS CAL KEY MISSING OR CORRUPT** (AutoCAT™2 Wave units only)

The FOS Catheter Calibration Key is not inserted or corrupt.

#### **AP FOS SENSOR OUT OF RANGE** (AutoCAT™2 Wave units only)

The FOS Catheter has at least one of the following problems:

1. AD Ratiometric Error exists.
2. Pressure is outside Barometric pressure limits
3. FOS Optical Block temperature exceeds limits.
4. Pressure is outside pressure limits.
5. There is an excessive pressure offset.
6. FOS indicating strong light from sensor.

### **DRAIN FAILURE**

Drain task has failed to complete after 8 tries to open drain valve.

### **DEFLATE MARKER SET BEYOND 100 PERCENT**

In OPERATOR MODE: In any ECG triggering mode except AFIB, deflation timing is set at or beyond 100%.

### **TIMING ERROR**

In OPERATOR MODE: Timing has been set such that deflation-to-inflation duration is less than 100 milliseconds. This is current rhythm dependent.

### **WARNING BATTERY INOPERATIVE**

Battery power circuit breaker is tripped or open.

### **AVAILABLE BATTERY POWER LESS THAN 5 MINUTES**

Amount of battery power remaining to operate the system is less than 5 minutes, power-down is imminent.

## **4. Troubleshooting**

### **4.1: Alarm Classification**

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#### **AVAILABLE BATTERY POWER LESS THAN 10 MINUTES**

Amount of battery power remaining to operate the system is less than 10 minutes, power-down is imminent.

#### **AVAILABLE BATTERY POWER LESS THAN 20 MINUTES**

Amount of battery power remaining to operate the system is less than 20 minutes.

#### **SYSTEM RUNNING ON BATTERY POWER**

AC power source had become unavailable, system is running on battery.

#### **VALID ECG TRIGGERS DETECTED**

In OPERATOR MODE: Valid ECG triggers are detected when the system is in INTERNAL triggering mode.

#### **WEANING STEP COMPLETE**

The currently programmed weaning step has been completed.

#### **ARTERIAL PRESSURE ALARM**

AP has fallen below set alarm limit.

#### **LOW HELIUM TANK PRESSURE**

Helium tank pressure is less than 100PSI.

The Class 4 Alarms which are described in the following section will cause the system to react by:

Displaying a Diagnostic Message.

### **CLASS 4 ALARM CRITERIA**

#### **POSSIBLE LATE DEFLATION**

In AUTOPILOT MODE: Deflation time is long (due to slow balloon), or Pre-Ejection Period (PEP) is too short while in ECG trigger mode.

#### **ERRATIC TRIGGERING**

In AUTOPILOT MODE: Cannot find a reliable ECG source to trigger on. Pump switches leads at least 4 times within one minute.

#### **ECG LEAD FAULT (lead)**

In AUTOPILOT MODE: ECG skin lead (s), or ECG lead cable trunk, or ECG cable Nicolay connector disconnected, or 3-lead cable is connected, or cable defective.

In OPERATOR MODE: Inactive ECG skin lead(s) has a lead fault.

#### **NO ECG SIGNAL AVAILABLE**

In AUTOPILOT MODE: There is no ECG trigger, or the lead is noisy, or has a lead fault on the 5 ECG sources: I, II, III, V and Monitor

#### **NO AP SIGNAL AVAILABLE**

In AUTOPILOT MODE: There is no AP trigger on any of the 3 AP sources: Xducer, Monitor, and FOS.

#### **ARRHYTHMIA TIMING NOT AVAILABLE**

In AUTOPILOT MODE: Pump can not select AFIB trigger mode although there is arrhythmia present and arrhythmia timing is ON, due to bad PEAK scores on all leads.

#### **WARNING: DEAD CLOCK BATTERY**

Real time clock backup battery cannot refresh real time clock RAM.

#### **WARNING: LOW BATTERY FOR STATIC RAM**

Power-on self test indicates that the RAM cell will not hold a test pattern, suspected RAM backup battery low.

## 4. Troubleshooting

### 4.1: Alarm Classification

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#### Troubleshooting Guidelines

In the event that a problem may occur, the following table may help guide you to the most probable cause of some possible problems.

Problem	Possible Cause	Possible Solution
IABP will not power on	Not connected to AC power and DC circuit breaker off	Connect to an AC power source. Check POWER INDICATOR LED on the front panel. It should be illuminated when the IABP is connected to AC power.  Check DC circuit breaker in helium compartment. It should be in the ON position.
	Not connected to AC power and battery is discharged	Connect to an AC power source. Check POWER INDICATOR LED on the front panel. It should be illuminated when the IABP is connected to AC power.
	Faulty main power supply	Test outputs of main power supply, replace if necessary.
Powers on but no display on LCD	Defective umbilical cable	Replace umbilical cable.
	Defective internal cable	Replace internal cable between CPU pcb and umbilical connector.
	Faulty LCD	Replace LCD or entire Control Module.
	Faulty main power supply	Test outputs of main power supply, replace if necessary.
	Faulty CPU pcb.	Replace CPU pcb.
Pump motor will not move or moves erratically	Faulty motor driver	Replace motor driver
	Faulty main power supply	Test outputs of main power supply, replace if necessary
	Faulty pump mechanism	Replace pump mechanism
No response from keyboard	Faulty keyboard	Replace keyboard

#### Common Operational Problems

The AutoCAT™2 Series has internal diagnostic mechanisms to notify you of console or catheter malfunctions. The possible causes and suggested corrective actions will be displayed on the LCD. It is important to pay attention to alarms and to respond immediately if the pump shuts down. If the pump shuts down, the balloon will deflate automatically. However, allowing a deflated balloon to remain dormant is hazardous. A deflated balloon does not provide valuable cardiac assist to the patient and thrombus formation can occur if blood becomes trapped in the folds of the deflated balloon.

If a pump shutdown occurs, note the time and call hospital personnel knowledgeable in the maintenance of the AutoCAT™2 Series. If repair and pumping cannot be accomplished within 15-20 minutes, use a 50/60 cc syringe to rapidly inflate and deflate the balloon several times. This will reduce the risk of thrombus formation, but should be used only as an emergency procedure for short periods of time while awaiting the physician's arrival. The physician should consider removing the balloon. Arrow International recommends that you have a back-up IABP system available in case of a pump shutdown.

The troubleshooting tables in this chapter are designed to help you identify and correct problems quickly. In addition, you can identify and correct helium leaks by following the Leak Testing procedure described in section 4.4. If you are unable to correct EMI or any other problem with your system, call your local Arrow International Field Service Representative or call our 24-hour IABP service hotline 1-800-447-IABP (4227) or 1-617-389-8628 (outside the U.S.A. and Canada).

In addition, help is available for most functions. Simply press the HELP key for startup help or press HELP then a function key for specific key-related information.

## 4. Troubleshooting

### 4.2: Common Operational Problems

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#### Common Operational Problems

The table below describes the possible causes and corrective actions for many common operational problems. Where appropriate, there are references to sections in this manual for further information. If you do not find your problem in this table look in the other troubleshooting tables in this section. Always respond immediately to a pump shutdown.

COMMON OPERATIONAL PROBLEMS		
Problem	Possible Cause(s)	Corrective Actions
Console does not turn on when power switch is pressed	CPU does not start up  Console fuse blown	Power pump OFF then ON. If problem persists use another console. Contact field service.  Contact qualified hospital personnel or your Arrow International Field Service Representative; use correctly rated fuses only.
Pump operates in AC power but does not operate in battery	Circuit breaker switched off	Console not connected to AC and circuit breaker off. Switch on circuit breaker in helium compartment.
No audible tone for control keys	Volume control too low  Key Click off	Use AUDIO LEVEL in multi-function keys to raise the volume (Section 3.3). Key tone and alarm tone may be set independently.  Turn on Key Click.
No flashing heart symbol on LCD	Invalid trigger selected  ECG too small	Change trigger mode.  Autogain may be insufficient—increase ECG gain via >GAIN key—consider using MAN GAIN.
No ECG waveform displayed	Incorrect ECG source selected  Defective connections	Check ECG signal source, then select that ECG lead - i.e. I, II, III, AVR, AVL, AVF, V  Check electrodes and cable connections; repair or replace as required.

COMMON OPERATIONAL PROBLEMS		
Problem	Possible Cause(s)	Corrective Actions
No ECG waveform displayed (cont.)	Monitor connected improperly	Make sure monitor connected via Phone-to-Phone cable to ECG MON input connector
	Defective ECG skin amplifier	Use an external ECG monitor connected to the ECG MON input connector to monitor ECG; call Arrow International for service
	Defective waveform display	Use the strip chart recorder or an external monitor connected to the ECG output connector to monitor ECG; call Arrow International for service
	Incorrect ECG Source selected	Check ECG signal source LED. Change source by pressing SELECT key.
AC interference in ECG waveform (50/60Hz interference)	Reference electrode detached	Reattach reference ECG electrode
	Lead wires close to AC source	Poor electrode contact, attach new electrodes to patient
	Inappropriate trigger mode selected	Bundle ECG lead wires together and route them close to patient
Noisy ECG	Excessive muscular artifact	Select another trigger mode
	Skin inadequately prepared	Check electrode contacts and disposable electrode sites; place electrodes on bony prominences
	Electrodes placed improperly	Repeat skin preparation, then apply new electrodes
Wandering ECG baseline	Poor electrode contact	Apply new electrodes to proper locations
	Respiratory movements picked up by patient cable yoke	Attach new electrodes
		Move the patient cable yoke away from the abdomen and ventilator equipment
		Consider use of MAN GAIN until problem can be corrected.

## 4. Troubleshooting

### 4.2: Common Operational Problems

COMMON OPERATIONAL PROBLEMS		
Problem	Possible Cause(s)	Corrective Actions
Wandering ECG baseline (cont.)	Electrodes placed improperly	Apply new electrodes to proper locations
	Catheter or needle occluded	Flush and fill the catheter
	Defective transducer	Replace pressure transducer
	Defective amplifier	Use external AP monitor connected to the ART PRESS input connector to monitor Arterial Pressure; call Arrow International for service
	Incorrect source selected	Check AP signal source LED. Change source by pressing SELECT key.
	Defective waveform displayed	Use strip chart recorder or an external monitor connected to the ART PRESS output connector to monitor Arterial Pressure; call Arrow international for service
Transducer cannot be zeroed or calibrated	Defective transducer	Replace transducer
	Improper calibration procedure attempted	Disconnect all AP pressure cables and press the CAL key then Reset 100mm/V CAL then AUTO 100mm/V. Reconnect AP cables and follow calibration instructions in Section 7.1 in Operators Manual
Zero baseline drifts	Defective transducer	Replace transducer
Erratic pressure display	Defective transducer	Replace transducer
Helium loss	Leak in pneumatic system or in balloon	Perform Leak Test and repair as necessary (Section 4.4)
	Blood in catheter	Stop pumping and remove balloon immediately
	Late Deflation	Assess deflation point and adjust earlier.
	IAB too large	BPW plateau pressure exceeds AUG by more than 25mm—reduce IAB volume.
	Persistent erratic trigger or arrhythmias	Move deflate earlier, change trigger mode to PEAK, change assist ratio to 1:2.

## 4. Troubleshooting

### 4.2: Common Operational Problems

COMMON OPERATIONAL PROBLEMS: AutoPilot™ MODE			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Excessive Lead Switching	AutoPilot™	Low voltage ECG	Change to another lead Increase ECG Gain using the > key
		Abnormal or unusual ECG	Change to another ECG lead
		Noisy ECG	Check ECG connections Replace ECG electrodes/cable as needed Change to another lead Select Manual ECG gain
Incorrect or Wandering Timing	AutoPilot™	Inconsistent triggering	Select Operator Mode and select best ECG signal
		Noisy or poor ECG	Check trigger selection Select Operator mode and choose consistent trigger mode
		ECG Noisy Poor ECG waveform quality	Check ECG connections Replace ECG electrodes/cable as needed Change to another lead Select Manual ECG gain
Excessive Trigger switching	AutoPilot™	Changing patient condition	Select Operator mode Select optimal IABP settings

## 4. Troubleshooting

### 4.2: Common Operational Problems

LightWAVE™ SENSOR TROUBLESHOOTING			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
No signal	AutoPilot™ Operator	Sensor disconnected  Optical sensor block dirty  Failure or break in LightWAVE™ sensor  LightWAVE™ electronics failure	Reconnect sensor  Change optical sensor block Call Field Service  Change IAB or use an alternate AP source.  Replace IABP console. Use an alternate AP source. Call field service.
Inaccurate AP LightWAVE™ readings	AutoPilot™ Operator	Sensor not zeroed (LightWAVE™ icon blue)  CAL key changed  Sensor used at an altitude greater than 10,000 ft (3048 M)  LightWAVE™ electronic temperature out of range  Failure or break in LightWAVE™ sensor	No action. Use an alternate AP source for patient assessment and treatment.  Reinsert original CAL key.  Do not use LightWAVE™ sensor above 10,000 ft. Use an alternate AP source  Replace IABP console. Use an alternate AP source.  Replace IAB or use an alternate AP source
Noisy signal	AutoPilot™ Operator	IAB catheter whip	Check IAB position. Reposition as needed

## ESIS

ESIS minimizes the interference problems caused by electrosurgical/cautery devices. However, some ESU devices cause more severe interference problems than others: in some cases, particularly with older cautery systems, completely eliminating interference with the ECG waveform may not be possible. The table below provides suggestions for correcting excessive interference problems.

TROUBLESHOOTING ESIS		
Problem	Possible Cause(s)	Corrective Actions
<b>CAUTION:</b> <b>ESIS is operational at all times, however, it is most effective when a four- or five-lead ECG cable is used</b>	Poor ECG lead contact	<ul style="list-style-type: none"> <li>Check electrode-to-skin contact; reattach electrode if necessary</li> <li>Check connections at lead tip and cable junctions; repair if necessary</li> <li>Replace the ECG cable</li> <li>Use back pad electrode</li> </ul>
	Incorrect ECG lead selected	Change lead selection in the ECG SOURCE SELECT section of the keypad
	Lead wires positioned improperly	Place lead wires so they are away from the electrocautery cable and at a 90° angle from the cables
	High electrocautery setting	<ul style="list-style-type: none"> <li>Use minimum ESU required for adequate cutting and setting</li> <li>Change to ART PRESS trigger mode</li> </ul>
	Ground plate positioned improperly	Place ground plate under back and under the surgical site
	Electrodes placed on patient improperly	Change electrode placement (leads may be placed on the posterior aspect across the shoulder axis if necessary); check lead selection
Persistent electrosurgical interference	Cables placed improperly	Place cables so they are away from the electrocautery cable and at a 90° angle from the cables
Display scrambled or corrupted	Excessive ESU Interference	Disconnect cable from LCD unit momentarily and reattach

## 4. Troubleshooting

### 4.2: Common Operational Problems

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TROUBLESHOOTING ESIS		
Problem	Possible Cause(s)	Corrective Actions
Absent or poor ECG waveform	ECG Cable connected improperly  Poor ECG lead contact  Incorrect lead selected  ECG source improperly selected  Electrodes placed on patient improperly	Make sure the ECG cable is connected to the correct connector on the AutoCAT™2  • Check electrode-to-skin contact; reattach electrodes if necessary  • Check connections at lead tip and cable junctions; repair if necessary  • Check ECG source and change if needed  Check electrode placement (leads may be placed on the posterior aspect across the shoulder axis if necessary); check lead selection
Intermittent or absent flashing heart or white trigger bands	Inappropriate trigger mode selected  ECG Gain affected by ESIS interference	Change trigger mode  Consider using MAN GAIN

## 4.2 Diagnostic Alarms

The AutoCAT™2 Series alarm system notifies you of certain potential or actual problems and suggests corrective steps: always respond to alarms promptly. The tables on the following pages provides additional information about the automatic response and information only alarms.

1. To disable alarms, press ALARMS ON/OFF key. Select the amount of time for ALARMS OFF (10 to 60 minute increments). The time remaining for the ALARMS OFF period will be displayed to the left of the ECG. A warning message will appear above the ECG.
2. To change the audio level, select AUDIO LEVEL in the multi-function keys of the keypad and adjust appropriately.

### **WARNING**

Do not turn off alarms except for brief period while correcting an alarm condition. After the alarm condition has been corrected, enable the alarms by pressing the ALARMS ON control key.

#### **AUTOMATIC RESPONSE ALARMS (Class I)**

<b>Problem</b>	<b>Operation Mode</b>	<b>Possible Cause(s)</b>	<b>Corrective Actions</b>
System Error 1 Incorrect Pressure Level	AutoPilot™ Operator	Pneumatic pressure level out of range.	Press Alarm reset. Press pump ON to resume pumping. If this does not correct problem then turn power OFF then ON.  If alarm persists, change IABP console. Call field service.
System Error 3 Pump/Valve Controller Failure	AutoPilot™ Operator	Pneumatic system failure	Press Alarm reset. Press pump ON to resume pumping. If this does not correct problem then turn power OFF then ON.  If alarm persists, change IABP console. Call field service.
System Error 4 Main CPU Failure	AutoPilot™ Operator	Computer failure	Press Alarm reset. Press pump ON to resume pumping. If this does not correct problem then turn power OFF then ON.  If alarm persists, change IABP console. Call field service.

## 4. Troubleshooting

### 4.2: Troubleshooting Alarms Class I

AUTOMATIC RESPONSE ALARMS (Class I)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
System Error 6	AutoPilot™ Operator	CPU failure	Press Alarm reset. Press pump ON to resume pumping. If this does not correct problem then turn power OFF then ON.  If alarm persists, change IABP console. Call field service.
System Error 7 Keyboard Controller Failure	AutoPilot™ Operator	Umbilical cable disconnected at control head or at console.  Control head hardware failure	Check umbilical cable connections. Reconnect as needed. If alarm persists, power the pump OFF then ON.  Change control heads or IABP console. Call field service.
System Error 8 (AutoCAT™2 WAVE Only)	AutoPilot™ Operator AutoCAT™2 WAVE only	LightWAVE™ hardware failure	Change IABP console. Call field service. Select an alternate Arterial pressure source. If problem persists, turn pump OFF then ON.
Unable to Refill	AutoPilot™ Operator	Low Helium tank pressure  Fill/Drain valves malfunctioning  Insufficient deflation time	Check HE tank. Change as needed.  Change IABP console and call field service.  Check timing. If deflation time is very short, i.e. there is no visible BPW baseline, switch to Operator mode.
Unable to Refill	Operator	Incorrect timing	Verify Operator mode. Adjust timing until BPW baseline is visible during IAB deflation.  If problem persists, select 1:2 assist ratio. Change IABP console

## 4. Troubleshooting

### 4.2: Troubleshooting Alarms Class I

<b>AUTOMATIC RESPONSE ALARMS (Class I)</b>			
<b>Problem</b>	<b>Operation Mode</b>	<b>Possible Cause(s)</b>	<b>Corrective Actions</b>
Possible Helium Loss	AutoPilot™ Operator	Leak in Tubing or Connections	Perform Leak test and repair tubing as needed
		Kinked Catheter	Find kink and straighten out the catheter
		IAB has not fully exited the sheath	Be sure the IAB has exited the sheath
		Balloon connector not properly seated	Disconnect and reconnect the IAB connector
		Blood in catheter tubing	Remove balloon immediately and insert a new IAB catheter
		IAB too large	<b>WARNING</b> Any evidence of blood leakage within the IAB assembly warrants immediate IAB removal.
		Erratic triggering or arrhythmia's Incorrect timing	Reduce IAB volume  Change assist ratio to 1:2 Reduce IAB volume. Select Operator mode and select PEAK trigger and reset timing
		Very late deflation or early inflation	Change to 1:2 assist. If alarm condition does not occur, return to 1:1 and adjust timing so BPW baseline may be observed. NOTE: If HE loss continues in 1:2 assist, perform leak test.
	Operator only	Erratic triggering or arrhythmia's	Change to PEAK trigger mode. Set deflation earlier.
		Kinked IAB Driveline	Check tubing for kinks. Find and straighten kink.
High Pressure	AutoPilot™ Operator	IAB has not exited the sheath	Verify IAB is out of sheath. Reposition IAB as needed.

## 4. Troubleshooting

### 4.2: Troubleshooting Alarms Class I

AUTOMATIC RESPONSE ALARMS (Class I)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
High Baseline	AutoPilot™ Operator	Partially wrapped IAB	Notify physician; aspirate IAB, if no blood is present inject 50cc of air into the balloon and aspirate and remove syringe from IAB connector.
		Balloon Too Large for the Aorta	Check BPW/AP relationship. Decrease IAB volume if indicated.
		Kinked catheter	Find kink and straighten out catheter.
		IAB has not exited the sheath	Verify IAB is out of sheath. Reposition IAB as needed.
		Partially wrapped balloon	Notify physician; aspirate IAB, if no blood is present inject 50cc of air into the balloon and aspirate immediately.
		Overfill	Call Arrow International for service
Large Helium Leak	AutoPilot™ Operator	Improper IAB position	Verify IAB position and reposition as needed.
		IAB tubing disconnected or IAB disconnected from console	Check all IAB connections for leak. Reconnect and/or tighten as needed.
		Quick connection on IAB is not tightly connected	Tighten quick connection
		Leak at IAB connection or in Tygon tubing between console and catheter insertion point.	Verify tight connections at all driveline tubing connection points.
		Other helium leak Check for blood in tubing. If blood is observed remove and replace IAB. If no blood is observed, perform leak test.	Perform leak test. Replace or repair IAB as needed.

**4. Troubleshooting**  
**4.2: Troubleshooting Alarms Class I/II**

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**AUTOMATIC RESPONSE ALARMS (Class I)**

Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Purge Failure	AutoPilot™ Operator	No trigger or reliable trigger signal lost.  Helium tank not open or inserted properly.  Helium tank empty.  Prior alarms not reset.  IAB not connected	Check patient. Verify trigger bands are present on ECG and AP. Verify flashing heart and HR corresponds to patient.  Select Operator mode and choose appropriate trigger mode.  Check helium tank. Change as needed.  Replace HE tank  Verify alarms are reset. Reset alarms as needed.  Check IAB connections Attach IAB connector.

**AUTOMATIC RESPONSE ALARMS (Class II)**

Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Standby Alarm Disabled	AutoPilot™ Operator	Stand-by alarm disabled indefinitely	Press pump OFF. Press pump ON to resume counterpulsation.
Standby longer than 3 MIN	AutoPilot™ Operator	Pump in standby for longer than 3 minutes	<ul style="list-style-type: none"> <li>• Press RESET to clear alarm (Alarm will be re-issued in 3 minutes)</li> <li>• Press pump OFF</li> <li>• Press pump ON to resume counterpulsation</li> <li>• Press Pump Stand-by Twice to place pump in Stand-by mode indefinitely.</li> </ul>

## 4. Troubleshooting

### 4.2: Troubleshooting Alarms Class II

AUTOMATIC RESPONSE ALARMS (Class II)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
ECG Trigger Loss	Operator only	No ECG waveform displayed	<ul style="list-style-type: none"> <li>• Check patient condition/rhythm.</li> <li>• Check electrode placement and change if necessary.</li> <li>• Check ECG cable connections; reconnect as needed.</li> <li>• Check external monitor connection at monitor and IABP input.</li> <li>• Check/change ECG lead. Check/change ECG source.</li> </ul>
		Waveform erratic or noisy	<p>Reapply electrode paste or disposable electrodes.</p> <p>Consider using Manual gain</p>
		Low waveform amplitude or biphasic QRS complexes	Select another lead (if using external monitor, change lead on monitor). Increase size using gain controls.
Pressure Trigger Loss	Operator only	Inappropriate trigger mode selected.	Select another trigger mode and reset timing as needed.
		No pressure waveform displayed	<ul style="list-style-type: none"> <li>• Check patient condition</li> <li>• Check all connections.</li> </ul> <p>Make sure correct AP Select source is selected.</p> <ul style="list-style-type: none"> <li>• Check pressure transducer, IAB catheter and connections for loose connections, repair/tighten if necessary.</li> <li>• Select another trigger mode.</li> <li>• Re-Zero AP source.</li> </ul>
		LightWAVE™ AP sensor (AutoCAT™2 WAVE only)	<p>AP sensor cable disconnected</p> <p>Check connections and reconnect as needed.</p> <p>AP sensor cable broken</p> <p>Replace IAB. Select an alternate AP source.</p>

**4. Troubleshooting**  
**4.2: Troubleshooting Alarms Class II**

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<b>AUTOMATIC RESPONSE ALARMS (Class II)</b>			
<b>Problem</b>	<b>Operation Mode</b>	<b>Possible Cause(s)</b>	<b>Corrective Actions</b>
ECG Lead Fault Detected	AutoPilot™ Operator	CAL key not inserted or corrupted.	Insert CAL key. Change IAB catheter. Use alternate AP source.
		LightWAVE™ connector needs to be replaced or cleaned.	Replace LightWAVE™ connection. Clean LightWAVE™ sensor connection point. Call field service.
		LightWAVE™ electronics failure.	Replace console. Use an alternate AP source. Call field service.
		LightWAVE™ electronic temperature out of range.	Replace console. Use an alternate AP source. Call field service.
		Altitude above 10,000 ft.	Use alternate AP source.
		Poor electrode connection	Re-apply electrode paste or replace disposable electrodes
		Loose connections	Check ECG cable connections; repair/reconnect as needed. Replace ECG cable.
		3 lead cable detected	Use 5 lead ECG cables only
Trigger Loss	AutoPilot™ only	Phono to Nicolay cable detected	Use a Phone to Phone cable for slaving
		No ECG/AP/Pacer trigger can be found	Check patient condition Switch to Operator mode Check ECG/AP sources and change as needed.
		Very small ECG signal	Use ECG gain to increase ECG size.

## 4. Troubleshooting

### 4.2: Troubleshooting Alarms Class III

INFORMATION ONLY ALARMS (Class III)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
AP FOS Signal Weak	AutoPilot™ Operator	AP sensor failure	Cable is broken. Replace IAB. Select and alternate AP source.
		AP sensor dirty	Clean LightWAVE™ AP contact point. Replace LightWAVE™ sensor contact.
		AP sensor partially connected	Disconnect and then reconnect AP LightWAVE™ sensor. Verify “click” is heard when sensor is connected.
AP FOS Sensor Out of Range	AutoPilot™ Operator	Electronics operating temperature too high or too low.  Altitude above 10,000 ft.	Select and alternate AP source.  Change altitude. Select and alternate AP source.
AP FOS Cal key missing or Corrupt	AutoPilot™ Operator	AP LightWAVE™ key not plugged into receptacle	Reconnect CAL key
		AP LightWAVE™ CAL key damaged	Replace IAB. Select an alternate AP source.
		Condensate bottle full  Drain tubing kinked  Drain valve failed to open or system purge not performed	Empty condensate bottle  Straighten drain tubing  Initiate purge cycle by pressing PUMP OFF then Stand-by, wait 5 seconds for purge, then press PUMP ON to resume pumping. Replace IABP console. Call field service.
Deflate Marker Beyond 100%	Operator only	Deflation set beyond the R wave	Check deflation timing. Set deflation earlier as needed.
Timing Error	Operator	Timing may be incorrect	Check timing. Adjust timing as needed.

## 4. Troubleshooting

### 4.2: Troubleshooting Alarms Class III

INFORMATION ONLY ALARMS (Class III)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Warning: Battery Inoperative	AutoPilot™ Operator	The AutoCAT™ 2 will not run in battery mode due to faulty circuit breaker  Circuit breaker turned OFF	Do not disconnect the AutoCAT™ 2 from AC power source. Check circuit breaker located in helium compartment.  Turn on circuit breaker
Available Battery Power Less than 5 minutes	AutoPilot™ Operator	Battery voltage low	Change to AC power as soon as possible to recharge batteries
Available Battery Power Less than 10 minutes	AutoPilot™ Operator	Battery voltage low	Change to AC power as soon as possible to recharge batteries
Available Battery Power Less than 20 minutes	AutoPilot™ Operator	Battery voltage low	Change to AC power as soon as possible to recharge batteries
System Running on Battery Power	AutoPilot™ Operator	AC power disconnected  AC power failure	Check AC power source. Reconnect the IABP to AC power  Arrange for alternate AC power source if failure is expected to exceed 90 minutes. If AC power is connected but not available, change IABP console. Call field service.
Valid ECG Trigger Detected	Operator	QRS complex detected while in INT mode.	Verify ECG is present. Change to ECG or AP trigger mode.
Weaning Step Complete	AutoPilot™ Operator	Weaning timer has expired	Evaluate patient hemodynamics and set parameters for next weaning step. If weaning is complete, remove IAB.

## 4. Troubleshooting

### 4.2: Troubleshooting Alarms Class IV

INFORMATION ONLY ALARMS (Class III)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Arterial Pressure Alarm	AutoPilot™ Operator	AP has fallen below set limit	Check patient hemodynamics. Check for AP disconnect.
Low Helium Tank Pressure	AutoPilot™ Operator	HE tank is empty HE tank is OFF	Change HE tank Open HE tank

AUTOMATIC ALERTS ALARMS (Class IV)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Possible Late Deflation	AutoPilot™	Electromechanical delay is less than 100 msec	Check deflation timing. If deflation timing is too late and patient hemodynamics are compromised, select Operator mode and manually adjust timing
Erratic Triggering	AutoPilot™	ECG connected from bedside monitor. Signal delay is longer than 35 msec  > 3 lead switches within 1 minute and no AP signal available  > 3 trigger switches between AP and Pacer within 1 minute	Consider using direct patient connection with 5 lead ECG cable.  Check ECG signal quality. Change ECG electrodes. Change ECG lead. Adjust Autogain or select Man gain. Select Operator mode.  Check patient condition. Select Operator mode. Select appropriate trigger mode.
No ECG signal available	AutoPilot™	ECG signal is not available but IABP is triggering on AP or pacer signal	Check ECG connections. Reconnect ECG cable or leads. Attach another ECG source from patient or monitor.

## 4. Troubleshooting

### 4.2: Troubleshooting Alarms Class IV

INFORMATION ONLY ALARMS (Class IV)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
No AP signal Available	AutoPilot™	AP signal is not available, but IABP is triggering on ECG or pacer signal	Check AP connections. Reconnect AP cable. Attach another AP source from patient or monitor.
ECG Lead Fault	AutoPilot™	ECG electrode disconnect  3 lead cable detected  Phono to Nicolay cable detected	ECG lead or cable disconnect but pump is pumping in an alternate trigger mode. Check ECG lead contact. Check ECG cable/lead connections. Reconnect ECG cable/lead. Replace ECG electrodes.  Use 5 lead ECG cables only  Use a Phone to Phone cable for slaving
Arrhythmia Timing Not available	AutoPilot™	Arrhythmia detected but AFIB trigger cannot be selected.	R wave deflation cannot be implemented due to user selection or noisy ECG. Check timing. If R wave deflation is desired, turn Arrhythmia timing ON. Select Operator mode. Select AFIB trigger mode. Check timing. Check ECG signal.
Warning: Dead Clock Battery	AutoPilot™ Operator	Internal Clock Battery Malfunction Call Field Service	Call Field Service Pump can remain on patient.
Warning: Low battery for static RAM	AutoPilot™ Operator	Internal Static RAM Battery Malfunction	Call Field Service Pump can remain on patient.

## 4. Troubleshooting

### 4.3: Balloon Pressure Waveform

#### 4.3 Balloon Pressure Waveform

The balloon pressure waveform displayed on the AutoCAT™2 LCD represents the dynamic actions of the helium shuttle gas during pumping. A properly functioning balloon usually produces the balloon pressure waveform and AP waveform shown in Figure 4.1.

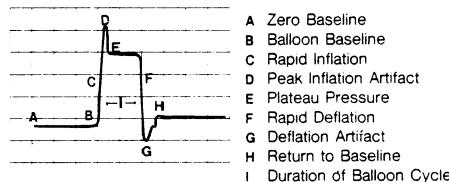
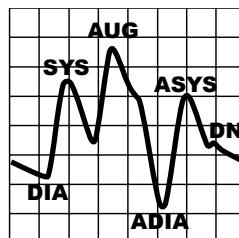


Figure 4.1: Normal Balloon Pressure Waveform



DIA - Diastolic Pressure  
AVO - Aortic Valve Opening  
SYS - Systolic Pressure  
AUG - Augmentation  
ADIA - Assisted Diastole  
ASYS - Assisted Systole  
DN - Dicrotic Notch

Figure 4.2: Properly Timed Arterial Pressure Waveform

Problems with the control system, IAB problems or certain patient conditions can cause distortions in the balloon pressure waveform. Troubleshooting these waveforms is often the best way to recognize and correct problems. Being familiar with the waveforms in this section can help you maximize the clinical benefits of IABP to the patient.

Some of the abnormal balloon pressure waveforms in this section may initiate one or more alarms. This is because the AutoCAT™2 detects incorrect pumping volume, abnormally high balloon pressure, helium loss and catheter or tubing obstructions by monitoring balloon pressure. By monitoring the patient's status as well, the AutoCAT™2 Series can identify balloon occlusion and reduced augmentation.

The BPW plateau has a normal and expected relationship to the AUG of the patient. The BPW plateau and AUG should be within 20-25 mmHg of each other. You may want to use the cursor to verify the BPW plateau pressure.

#### Squared Waveform

Three causes of a squared balloon pressure waveform (Figure 4.3) are listed below.

1. There is a kink in the catheter, sheath or balloon membrane.

Examine the catheter for kinks, then straighten out the catheter. Verify that the IAB membrane has completely exited the insertion sheath.

2. The balloon has not unwrapped.

Notify the physician. Aspirate approximately 50 cc of air then inject approximately 50 cc of air into the balloon connector and aspirate or disconnect the syringe from the IAB connector.

3. The IAB is occlusive.

Select BALLOON VOLUME and decrease the balloon inflation volume. Observe the balloon pressure waveform. Repeat this procedure until the waveform appears normal.

#### WARNING

If an IAB is suspected of being occlusive, do not reduce the IAB volume to less than 2/3 of the balloon's capacity. To prevent thrombus formation, pump the balloon at maximum capacity for five minutes every hour. A smaller IAB volume should be considered.

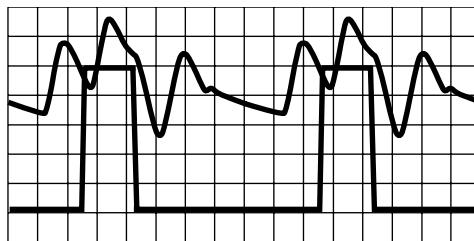


Figure 4.3: Squared Balloon Pressure Waveform

#### Reduced Augmentation

Reduced augmentation may result in a waveform characterized by a "low plateau pressure" (see Figure 4.3). Some causes of reduced augmentation are listed below.

1. **Balloon too small -**

Forward displacement of blood will be decreased since the blood will also be driven around the balloon.

2. **Balloon positioned too low -**

If the balloon is too low there is more area to try to displace volume and the balloon is not as effective.

3. **Hypovolemia - Patient is ready to wean from the IABP -**

Rationale: Best augmentation occurs when the patients stroke volume equals the balloon volume, ie. 40cc balloon will work best when patients stroke volume is 40cc's. If the stroke volume goes above or below the balloon volume the augmentation will decrease.

4. **Balloon is not unwrapped -**

If the balloon is not fully unwrapped it will be unable to displace the full volume and therefore augmentation will decrease.

## 4. Troubleshooting

### 4.3: Balloon Pressure Waveform

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#### 5. Late inflation -

When inflation occurs at the beginning of diastole there is a lot of blood in the aorta because systole has just occurred. If the balloon inflates too late, the blood in the aorta will run off into the periphery and therefore will not have as much volume to displace.

#### 6. Balloon positioned in the wall of the aorta instead of the vessel -

This would cause a false aneurysm, and the patient would most likely experience severe back pain. This would cause a decrease in augmentation because there would be minimal, if any, displacement of blood.

#### 7. Balloon volume not set at desired value -

All pumps automatically set volume when balloon is connected, however the balloon volume may have been decreased and not returned to full volume.

#### 8. Low systemic vascular resistance (SVR).

#### 9. Obstruction to gas flow -

Kinks in the driveline tubing or IAB catheter may obstruct flow to the balloon and reduce augmentation.

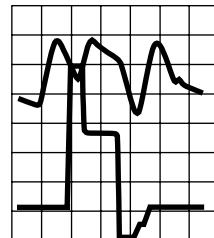


Figure 4.4: Balloon Pressure Waveform Reflecting with Arterial pressure Waveform showing reduced augmentation

### Baseline Below Zero

If the baseline of the balloon pressure waveform falls below zero as shown in Figure 8.4, there is probably a helium loss. The AutoCAT™2 will initiate the POSSIBLE HELIUM LOSS or LARGE HELIUM LEAK alarm (unless the system is in the ALARMS OFF mode). To correct this problem:

1. Press PUMP OFF to stop the pump.
2. Perform the Leak Test and repair any leaks found. Do not resume pumping until leaks have been corrected.

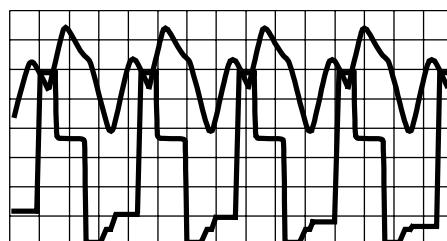


Figure 4.5: Balloon Pressure Baseline Below Baseline

#### 4.4 Leak Testing and Tubing Repairs

If a helium leak is suspected, follow the instructions below to check the pneumatics and the balloon connector. You will need a pair of rubber-shod hemostats and a spare balloon connector and tubing to perform the Leak Test. Call your Arrow International Sales Representative or service number for ordering information.

##### ***Leak Test***

1. Press the RESET control key in the ALARMS field to silence any audible alarms.
2. Press the ALARMS ON/OFF control key and select the 10 MIN key to disable the alarms for ten minutes.
3. Use a pair of rubber-shod hemostats or other clamping device to clamp the catheter tubing between the quick connect valve and the bifurcation.
4. Press the ON control key to start pumping.
5. Observe the balloon pressure waveform. If the baseline falls, the leak is probably between the pump and the clamp. If the baseline does not fall, the leak is probably on the patient side: consider stopping the pump, removing the balloon catheter and inserting another catheter.
6. Press the PUMP OFF control key and remove the hemostat.
7. Check the O-rings on the balloon connector, wipe off any debris and make sure that the connection at the quick connect valve at the IAB catheter bifurcation is tight.

Also, examine the tubing at the balloon connector and at the catheter junction. If the tubing appears to be stretched in either location, see the instructions below to repair the tubing.

8. Repeat steps 2-4. If the baseline remains steady, the leak has been corrected and you can resume pumping. If the baseline continues to fall, the leak is in the control system or the connector. Complete steps 9-10.
9. Press the PUMP OFF control key and remove the hemostat.
10. Remove the balloon connector, cut off 1/2" of tubing, replace the connector and repeat steps 2-4. If the baseline remains steady, the leak has been corrected and you can resume pumping. If the baseline continues to fall, there may be an internal console leak. Call Arrow International for service.
11. If the alarms are still disabled, press the ON control key to re-enable the alarms.
12. Press ALARM RESET to remove alarm messages.

## **4. Troubleshooting**

### **4.4: Leak Testing and Tubing Repairs**

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#### **Tubing Repairs**

1. To repair a tubing leak, wrap non-porous tape (e.g., electrical tape) around the tubing at the site of the leak.
2. To repair stretched tubing at the balloon connector, remove the compression ring and pull the connector off the tubing. Then cut off a 1/2 inch segment from the end of the tubing and reconnect the balloon connector and the compression ring.
3. To repair stretched tubing at the catheter junction, disconnect the tubing from the junction. Then cut a 1/2 inch segment from the end of the tubing and reassemble the junction.

If the leak is found at the QUICK CONNECT, Op-Site® or other occlusive, clear dressing material may be used to repair the leak.



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### CHAPTER 5: Theory of Operation

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#### Theory of Operation

The technical description for the AutoCAT™2 is presented in two parts. First, a functional description is outlined at system level, then at board level.

This section provides the detail of the various components and assemblies that make up the AutoCAT™2 IABP.

The contents of this chapter include:

<b>5.1: Functional Description System Level . . . . .</b>	<b>5-3</b>
Functional Description System Level . . . . .	5-3
Helium Flow . . . . .	5-4
<b>5.2: Functional Description Board Level . . . . .</b>	<b>5-6</b>
Main Power Supply and Battery Pack . . . . .	5-6
CPU PCB . . . . .	5-8
Front End PCB . . . . .	5-14
FOS . . . . .	5-23
Stepper Motor Driver . . . . .	5-25
Recorder . . . . .	5-25
Home Sensor PCB . . . . .	5-25
Control Module . . . . .	5-26
Keyboard Controller . . . . .	5-26
Modem . . . . .	5-27

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## Functional Description System Level

This section will very briefly outline the logical structure within the AutoCAT™2 and the basic paths that signals follow during normal operation. The detailed theory of operation in Section 5.2 provides an in depth look at all of the functions and sub systems of the AutoCAT™2.

There are essentially four types of signals used in the AutoCAT™2:

- Patient Input / Output Signals
- Operator Input / Output Signals
- Communication Signals
- Internal Data and Control Signals

The primary patient inputs / outputs for the AutoCAT™2 are electrical signals consisting of ECG, AP, and monitor signals. For the operator, the primary input is the keyboard, while the output can be in the form the LCD, the recorder, or the speaker. Other inputs and outputs to the system are the RS 232 data communications port, the modem, and the flashcard.

Patient inputs are applied to the front end board where they are amplified, filtered, and converted into a digital format before being passed on to the CPU board. Operator inputs from the keyboard are sent to the CPU. Note that the FOS Signal Input goes to the FOS BD for processing first, then to the Front End BD for additional processing.

The CPU in turn uses these inputs to control the action of the pump mechanism, which will result in a specific volume of helium gas being shuttled to and from the balloon to assist the patient. The CPU also uses these inputs to monitor the activity of the system, and issue information to the pump operator as necessary via the LCD and recorder.

An integrated power supply feeds the required voltages to the circuit boards and the pump mechanism.

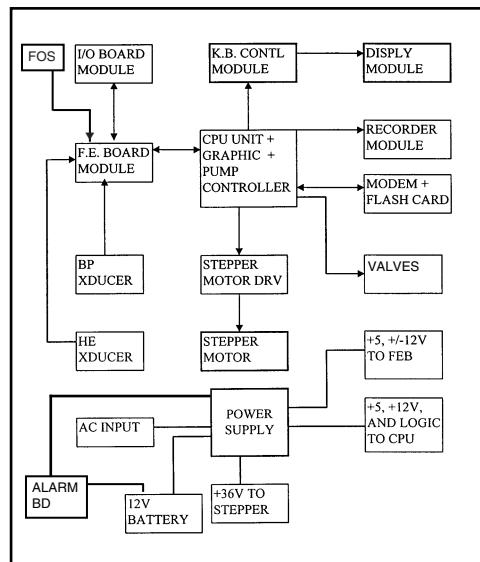


Figure 5.1: System Block Diagram

## 5. Theory of Operation

### 5.1: Functional Description System Level

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#### Helium Flow

The pneumatics system consists of a helium supply, a 2 stage pressure regulator, solenoid valves, relief valve, pressure transducer, and the pump assembly. These components control the gas filling, inflation/deflation and venting of the balloon. A diagram of the pneumatics system is shown in figure 5.1.

Initial helium pressure is approximately 500/2000/2900 psi (dependent upon which cylinder is installed). A pressure transducer on the regulator assembly continuously monitors the pressure in the helium cylinder and displays the remaining pressure in the cylinder as a bar graph on the LCD.

The high cylinder pressure is stepped down to 35 psi and again to 5 psi through a 2 stage regulator before it is applied, via a small orifice, to the first fill valve (V3). This valve when closed prevents the output from the 5 psi regulator from building up across the orifice and opening the relief valve; in the open condition it allows the system to be filled (or charged) with helium. The orifice allows only a predetermined volume (or charge) of helium to pass through the fill valves during each fill cycle.

Located just beyond V3 is a 1 psi relief valve which is a safety device that opens in the event that both fill valves (V3 and V2) remain open due to a catastrophic system malfunction. Should this condition occur, the maximum pressure applied to the balloon would be 1 psi (60mmhg). The second fill valve (V2) in the open condition allows the system to be filled; in the closed condition, it prevents the balloon drive pressure (or spikes) from coming back and venting the system by opening the relief valve. The vent valve (V1), a normally open valve, is fail safe in that it opens the system to atmosphere when it is de-energized. During filling and pumping the vent valve is closed, sealing the system from atmosphere and allowing helium to be applied to the pump assembly. A transducer, in line with the bellows/balloon tubing senses the pressure being applied to the balloon and converts this pressure to an electrical equivalent for use by the electronics system. A drain valve, in series with the balloon line, contains a solenoid valve (V4) that is actuated every 20 minutes for an approximate duration of 30 ms (depending on patient's heart rate) up to eight (8) consecutive beats to remove any moisture that may have accumulated in the balloon line tubing into a collection bottle. Since the pressure in the balloon line exceeds the external air pressure, air is prevented from being introduced into the system.

The Augmentation Valve opens during each cycle while the balloon is inflated, and closes before the deflation stroke occurs. This allows a small amount of helium to be isolated in the Augmentation Chamber. During the deflation period, as the balloon pressure is rising towards the baseline, the valve opens allowing the stored helium to be reintroduced back into the flow. This process enhances the deflation speed of the system.

**5. Theory of Operation**  
**5.1: Functional Description System Level**

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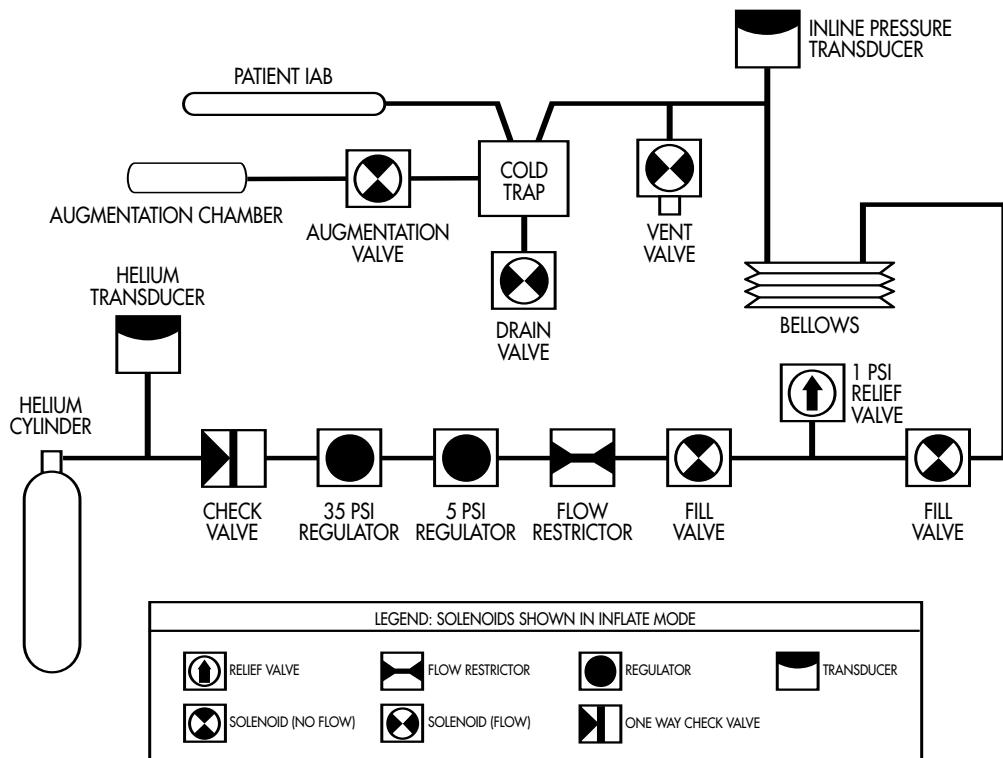


Figure 5.2: Helium Flow

## **5. Theory of Operation**

### **5.2: Functional Description Board Level**

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#### **Power Supply and Battery Pack**

The AutoCAT™2 power supply consists of a single assembly fully contained within its housing with several connectors for AC in, DC out, and logic control signals. This power supply generates all the necessary DC voltages to operate the AutoCAT™2 and the charging circuitry required to maintain the system battery. Power to and from the battery passes through a circuit breaker located in the helium tank compartment.

The AutoCAT™2 has a standard configuration of one battery for DC operation. An optional second battery can be installed for longer battery operation if desired. A single battery will power the system for approximately 90 minutes while the dual battery configuration will power the system for approximately 3 hours. If only one battery is installed it must be connected to charger output number 1.

#### **AC POWER INPUT**

There is a single AC input connector. It will accept an AC input voltage from 90 to 264 volts at frequencies from 47 to 63 Hz. The AC in to the power supply has both lines fused at the AC inlet module on the front panel of the AutoCAT™2. Both lines are additionally fused at a point internal to the power supply.

#### **DC POWER OUTPUTS**

The power supply produce and output the following regulated voltages: 5 volts, 12 volts, -12 volts, and 54 volts. The voltages are used by the operating system of the AutoCAT™2. The specifications for the acceptable ranges of the voltages can be found in Section 6 of this manual. All output voltages are fixed and there are no adjustments, either internal or external.

In addition, there are two battery charger outputs to maintain the AutoCAT™2's battery for DC operation. In DC operation these two outputs will serve as inputs to the power supply from the battery to operate the AutoCAT™2 system. The specifications for the acceptable ranges of the voltages can be found in Section 6 of this manual. These outputs are fixed and there are no adjustments, either internal or external.

#### **LOGIC CONTROL INPUTS AND OUTPUTS**

There are several logic signals into and out of the power supply.

The power supply is switched on when pins 1 and 2 of connector J6 are connected through the power switch on the front panel of the AutoCAT™2.

A signal is provided to illuminate a POWER INDICATOR LED on the front panel of the AutoCAT™2 at any time that the AutoCAT™2 is connected to AC power. This signal is also sent to the CPU PCB to indicate to the AutoCAT™2 whether the system is operating from AC power or from battery power.

A signal is provided to illuminate a BATTERY CHARGED LED on the front panel of the AutoCAT™2 when the battery is greater than 75% charged. This circuit is active only when the AutoCAT™2 is connected to AC power.

## 5. Theory of Operation

### 5.2: Functional Description Board Level

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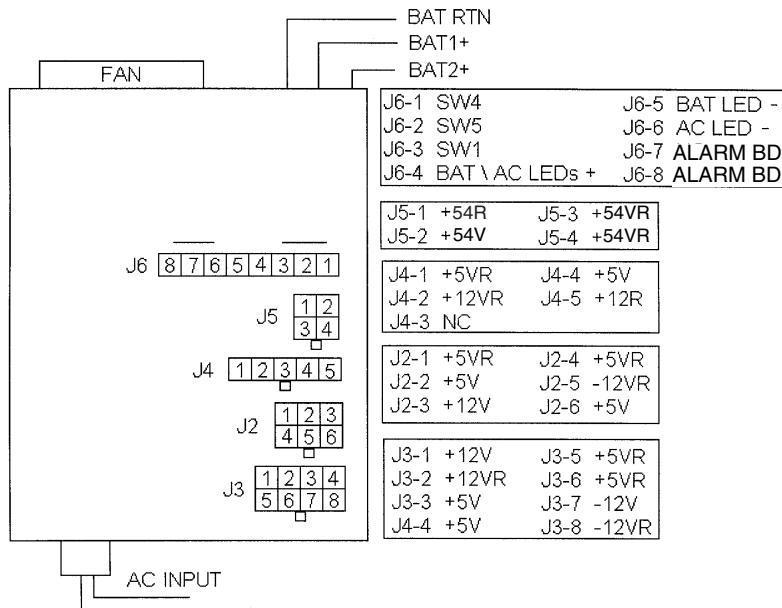


Figure 5.3: Power Supply Connector Diagram

### Alarm PCB

Working in conjunction with the power supply and battery pack is the Alarm pcb. This functions as a power monitoring alarm board. The purpose of this board is to monitor the +12 and +5 volt rails from the main power supply. If either of these voltages were to fail, the loss of voltage would enable a sonalert device mounted on the alarm pcb to produce a mono tone alarm. The alarm board itself is powered directly from the main battery, independent of the power supply.

There is also a connection from the power switch to the alarm pcb. In order for the sonalert device to produce the alarm tone when it detects a loss of voltage, the power switch must be in the on position. This prevents the alarm tone from being continuously produced when the power switch is off.

## 5. Theory of Operation

### 5.2: Functional Description Board Level

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#### CPU PCB

The CPU Board is responsible for scheduling, and processing of the data received from or transmitted to the peripherals. All the patient's data, pump status, and pump setting data (from the keyboard) are sent to CPU board. The CPU will process these data according to it's schedule; then it will send the processed data to output devices such as display, and recorder.

The CPU Board consists of a central processing unit, pump control unit, and graphic processor unit. The main central processing unit is a 32 bit Motorola 68332 microcontroller. The pump control unit is an 8-bit microcontroller (Phillips 87C51FC), which controls the pumping mechanism. A 32 bit graphic processor (TI 34010 processor) will drive the LCD display and the recorder module.

Front End Board, Keyboard Controller, and Modem modules are external peripherals connected to CPU by means of serial link. Front End Board will transmit or receives packed data to or from the CPU board every 4 ms.

Flash memory is mapped in the memory space of 68332 processor. A 34 x 2 connector connects the CPU board to a PCMCIA compatible Flash card.

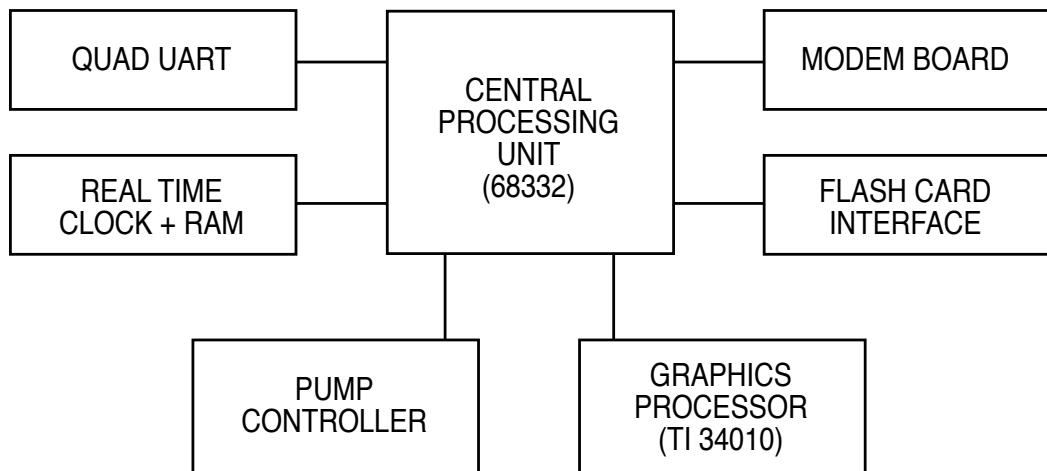


Figure 5.4: CPU Block Diagram

## MAIN PROCESSING UNIT

The main processing unit is responsible for overall scheduling, and processing of events. This unit consists of a 32 bit Motorola microcontroller, One Time Programmable Memory, NV RAM, RTC, and reset circuit.

The 68332 Microcontroller, PROMs, and the NV RAM are the basic blocks of the main processing units. The PROM units contain system application program.

The 68332 is a 32-bit integrated microcontroller, consisting of a CPU32 processor, Time Processor Unit (TPU), 2K Standby RAM, System Integration Module, and Que. Serial Module.

The CPU32 is based on a Motorola 68332 processor with internal Address registers, Data registers, and a 32 bit wide bus structure. The external data bus is 16 bits wide with 24-bit address lines (16 Meg. Byte linear address range). The instruction set for CPU32 is compatible with that of the 68000 family processors.

The Time Processing Unit (TPU) provides 16 channels for time related functions. Each channel can capture events, compare events, or could be used as an I/O pin.

The System Integration Module provides 12 chip select signals, external bus interface, test, and control signals. CSBOOT is the chip select signal for the PROM, CS0 - CS5 provide signals for RAM, UART, GRAPHICS, FLASH, and FLASH REGISTERS. CS9 and CS10 are used to write to LEDs and read Dip-switch positions

## PUMP CONTROLLER

The Pump controller unit is responsible for driving the pump assembly, by generating control signals going to stepper motor driver, and sensing the position of bellows. It will receive direction and volume displacement from the main processing unit (68332). Then it will generate the appropriate control signals for the stepper motor.

The pump control unit consists of an 8-bit microcontroller (87C51FC) with built in program memory, and stepper motor driver interface. The pump microcontroller communication with the main processor (68332) is established by a direct serial link. Each processor has a built in dedicated serial port (UART) which are directly connected together. The IRQ-HOME signal from pump controller indicates the state of Home Sensor to the 68332 processor.

## **5. Theory of Operation**

### **5.2: Functional Description Board Level**

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#### **GRAPHIC PROCESSOR**

The graphics portion of the CPU board consists of a TI Graphics processor (TMS34010), application memory (DRAM), Video memory (VRAM), LCD interface logic, and recorder interface logic.

During system initialization the main processing unit will load the application program into the graphics unit's DRAM. Then it will send graphics and text data to graphics unit on an ongoing basis.

The TMS34010 processor generates all the timing, and sequencing of Video signals. The graphic processor interfaces with the 68332 processor by means of a parallel interface. The Main processing unit (68332) accesses the graphics unit (TMS34010) through a 16-bit data bus.

#### **UART & LINE DRIVERS**

82C684 (U4) is a 4-channel Universal Asynchronous Receiver Transmitter unit (UART). This quad UART in conjunction with two Maxim line drivers (U5, U17) provides the interface for serial links such as Keyboard controller, FOS board, Modem (P1), and system RS232 port (JP1).

#### **FLASH MEMORY INTERFACE**

Flash memory interface logic will provide a PCMCIA compatible interface for flash memory card. It is mapped in linear space of the 68332 processor. The flash memory consists of two memory sections. One is the Card Information Structure (CIS) which is accessed by activating REG signal (NREG). The other is main memory, which is accessed by NFLASH chip select signal.

#### **MODEM INTERFACE**

The modem interface is established through an RS232 serial link between the main processing unit and Modem Board. The communication protocol is based on AT command structure.

**5. Theory of Operation**  
**5.2: Functional Description Board Level**

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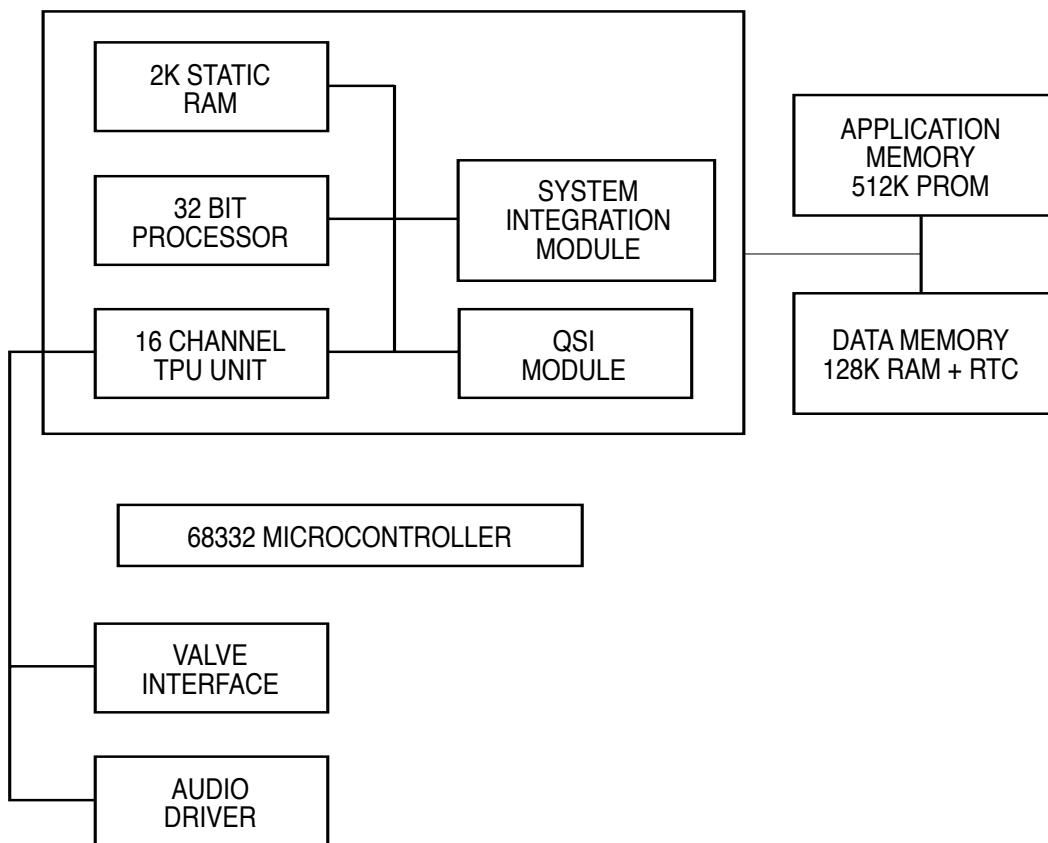


Figure 5.5: Main Processing Unit

## 5. Theory of Operation

### 5.2: Functional Description Board Level

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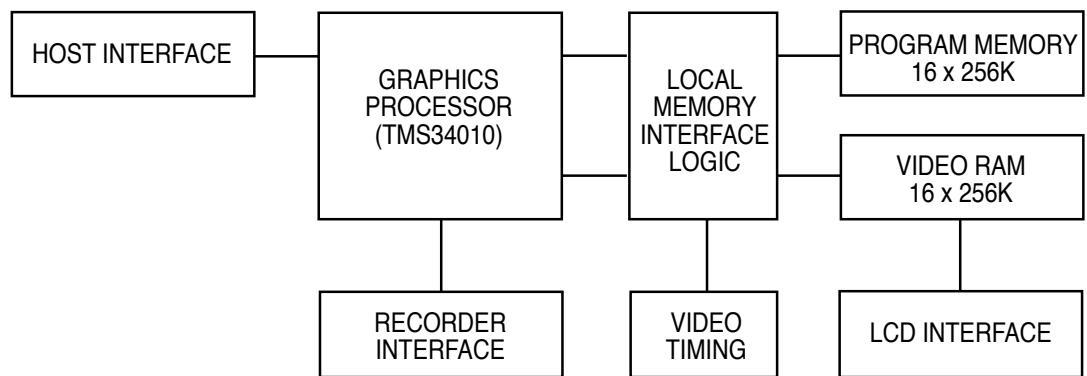


Figure 5.6: Graphics Processor

5. Theory of Operation  
5.2: Functional Description Board Level

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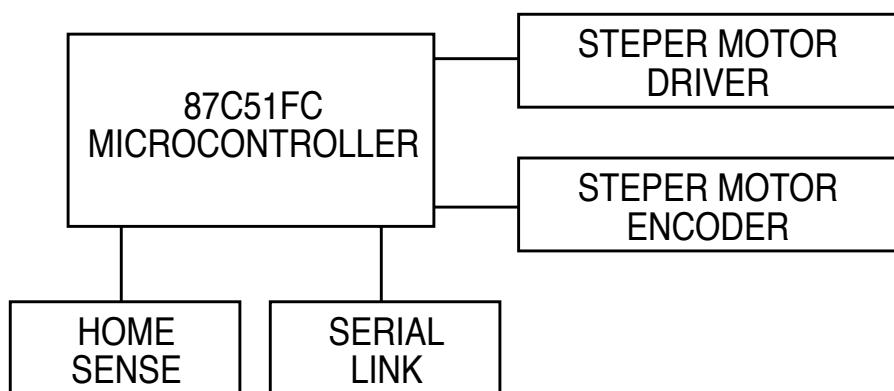


Figure 5.7: Pump Controller Unit

## 5. Theory of Operation

### 5.2: Functional Description Board Level

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#### FRONT END PCB

The Front End Board consists of three sections, isolated low level ECG, isolated low level AP, and a main circuit. This document first will describe the overall block diagram and functional description of the Front End Board and later it will cover the block diagram and theory of operation for each section of the board. Technical specification and analyses of digital filters will be attached as appendix.

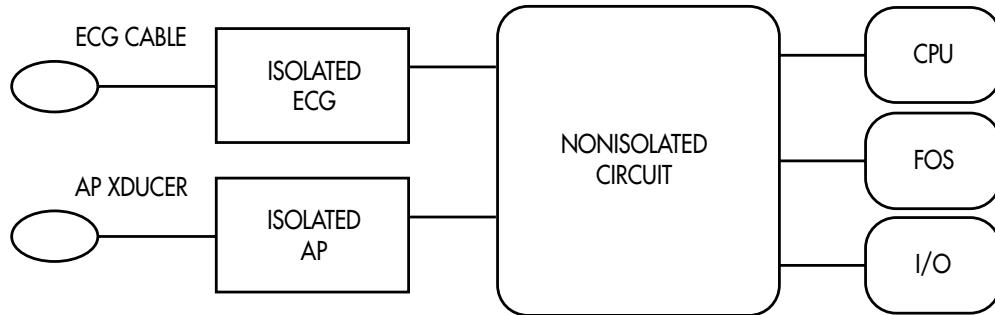


Figure 5.8: Front End Board Block Diagram

#### OVERALL DESIGN:

The Front End Board (77-1010) is designed to measure and process critical analog signals related to patient, and the AutoCAT™2 IABP. These signals are either inputs (low level ECG and AP), outputs (ECG, AP, and BP), or internal to the system such as helium BP, HE, or battery voltage.

The Front End Board is divided into three electrically isolated sections. These are isolated low level ECG, isolated low level AP, and main circuit which contains the high level input / outputs and internal signals. A three terminal power supply (BB 722) is used to supply isolated power to isolated ECG, and AP circuits.

The low-level ECG circuit will amplify, filter, convert, and isolate the low-level ECG signal. The isolated AP circuit will sense, amplify, filter, convert and isolate the low-level AP signal. The main circuit consists of non-isolated signals such as Balloon Pressure (BP), Battery, Helium, and balloon connector. It also consists of microprocessor and interface unit to the CPU.

#### ISOLATED LOW LEVEL ECG CIRCUIT(S)

The isolated low level ECG circuit consists of input protection, Elector-Surgical interference filter, 4 or 5 lead cable detection, input buffers, high pass filter, amplifiers, lead fault detection, serial A/D converter, opto-isolators, and isolated power supply.

## INPUT PROTECTION

The input protection circuit is designed to protect the sensitive low level ECG circuit from high voltages such as Defibrillators and Electro-Surgical Units (ESU).

The input protection is accomplished by using spark gaps in conjunction with current limiting resistors and clamping diodes. The spark gap will clamp the input voltage to a manageable level.

The current limiting resistors in series with the 1K resistor (embedded in the ECG cable) will limit the input current when over voltage is present.

The isolated low level ECG circuit consists of input protection, Electo-Surgical Interference Suppression, 3 or 5 lead cable detection, input buffers, multiplexers, high pass filter, amplifiers, lead fault detection, serial A/D converter, opto-isolators, and isolated power supply.

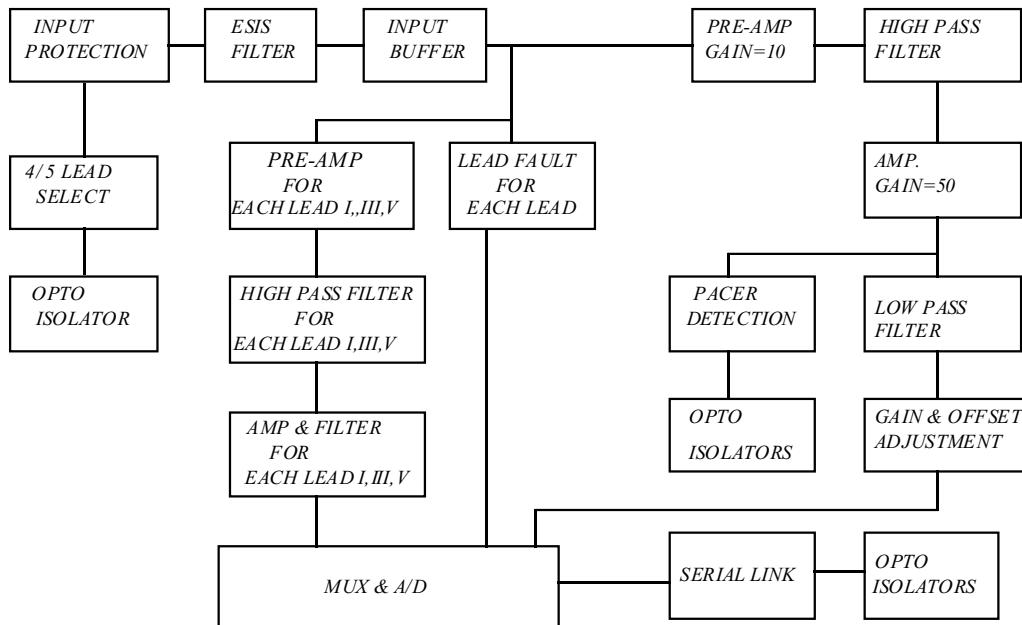


Figure 5.9: Isolated Low Level ECG Block Diagram

## 4 OR 5 LEAD CONFIGURATION

The patient ECG signal can be connected to the Front End Board either by a 4 or 5 lead ECG cable. In the 5 lead configuration, pin 5S (5 Lead sense) is connected to the isolated ground which in turn will drive 5/4-ECG-LEAD high. In this configuration RL lead is

## 5. Theory of Operation

### 5.2: Functional Description Board Level

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used as a reference and is driven by the average of the other leads. Leads I, II, III, and V have identical circuits. In this document lead II circuit is used as an example.

LEAD	SELECT (5 LEAD)	SELECT (4 LEAD)
I	LA, RA	LA, RA
II	LL, RA	LL, RA
III	LL, LA	LL, LA
V LEAD	C, (RA+LA+LL)/3	

#### ELECTRO SURGICAL INTERFERENCE FILTER

The next stage after the input protection circuit are the RC low pass filters on each lead signal to suppress the Electro Surgical Interference generated by an ESU. This frequency range will allow the low frequency ECG signal, and pacer signal to pass through.

#### INPUT BUFFER

At this stage two dual operational amplifiers buffer the ECG lead signals. The outputs of these buffers are used to drive the inputs of the RL drive summing amplifier. These outputs are also used to sense a lead fault condition, by being sampled at channels 4 through 7 of A/D converter.

#### AMPLIFIERS

The buffered ECG signals will be amplified by a factor of 10 at pre-amplifier U6. The amplified ECG signal is later filtered by a 0.75 HZ high-pass filter (U7) to eliminates any DC offset voltage.

The next stage is a 100 Hz low-pass filter, and an "OFF SCREEN DETECTION" circuit. Following the low-pass filter is an amplifier with gain and DC offset adjustment.

#### HIGH PASS FILTER

To block any DC offset voltage generated by the patient electrodes (+/- 300 mV), a high pass filter with the cutoff frequency of .75 HZ is used. This will block the DC components of up to +/- 300 mV. This circuit is the same for leads I, II, III, and V lead.

### LEAD FAULT AND PACER DETECTION

For detecting ECG lead fault, pull-up resistors R3, R21, R34, and R48 are used to force the ECG lead buffer output high for any lead which is disconnected. If any of the voltages present at channels 4-7 are greater than 2 VDC, a lead fault detect flag is set by the software.

For pacer detection a differentiator circuit (U10A) is used to pass signals with pacer characteristics. U9B will translate the output of this differentiator to logic high for pacer duration.

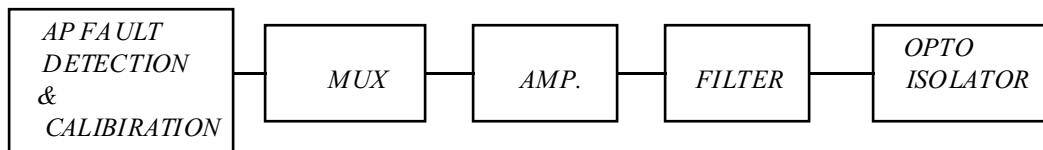
### SERIAL A/D CONVERTER

ECG leads I, II, III, and V (ECG-CH1 through ECG-CH3) are connected to the input channels of a serial 8-channel A/D converter. The A/D samples each channel at 250 Hz, and has a range of -2048 to +2048 mV. To eliminate aliasing of the converted signal, an anti-aliasing filter is used on all the ECG signals.

The serial data and control signals needed to communicate with the 68332-processor pass through U8, U20, and U21 Opto-Isolator.

### ISOLATED LOW LEVEL AP CIRCUIT

The isolated low level AP circuit consists of an arterial pressure transducer driver, AP fault circuit, calibration circuit, amplifier, low pass filter, and serial A/D converter. A multiplexer is used to sample the AP fault signal, -1 mV calibration voltage, or differential AP signal.



### TRANSDUCER DRIVER & AP FAULT CIRCUIT

The Arterial Pressure transducer requires an excitation voltage to operate. A 5 VDC voltage regulator (REF02) is used to supply +5 volt excitation to the transducer.

The differential output voltage of a transducer is 50uV/Cm hg/Volts. Therefore, for 5 volts excitation it will be 250uV/Cm hg or 25uV/mm hg.

When the AP transducer cable is not connected, Q3 will be "OFF" indicating an AP fault flag to 68332 processor. The AP fault detection is done by sensing the current going to the Xducer.

## **5. Theory of Operation**

### **5.2: Functional Description Board Level**

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#### **AMPLIFIER & FILTER**

The differential AP signal coming from the transducer is 25 micro-volt/mm hg; this signal needs to be amplified by a factor of 400 to get a 1 Volt/ 100 mm-hg signal. An instrumentation amplifier (U29) with the gain of 400 is used to accomplish this.

The amplified AP signal will be filtered by a two-pole low pass filter. This is an active filter with a cutoff frequency of 25 HZ.

#### **SERIAL A/D CONVERTER**

After the AP signal is amplified, and filtered it is converted to serial data by a 12 bit serial A/D converter (U30). The A/D converter has an input range of 0-+5V, and communicates with the processor through U32 and U33 opto-isolator.

#### **NON-ISOLATED CIRCUIT (MAIN CIRCUIT)**

The non-isolated circuit consists of high level ECG input/output, AP input/output, balloon pressure, helium, battery, and digital circuit (microprocessor & memory).

#### **HIGH LEVEL ECG AND AP CIRCUIT**

U43 is used as a differential amplifier which works as an input buffer for high level ECG input signal.

The next stage is a high-pass filter with a cut-off frequency of 0.75Hz. The output of this circuit (U43A) is connected to an amplifier for low frequency ECG components, and for high frequency pacer components. The branch for low frequency signals goes through a low-pass filter and later to the A/D converter. The branch for pacer detection will go through a differentiator which passes the signals in the range of pacer frequencies and blocks all other frequencies.

U74 is used as a differential amplifier which works as a buffer for high level AP input signal. The next stage is a low-pass filter to filter high frequency components. Following the filter is the 8-channel serial A/D converter that samples the signals at 250 Hz.

#### **BALLOON PRESSURE CIRCUIT**

The circuit for BP1 signal consists of a +5V excitation for BP transducer, instrumentation amplifier, and filter.

REF02 02 (U60) is the voltage regulator that generates +5 volt excitation to drive both balloon pressure and Helium Xducers.

The balloon pressure Xducer has a full range of 6 psi. The differential output voltage for the full range is 100 mV. To generate a balloon pressure signal of .4V/100 mmhg, the circuit requires a gain of 31. An instrumentation amplifier (U51) with the gain of 12 is used to amplify the BP signal coming from the transducer. A 25 Hz low-pass filter (U40A) is used to filter any noise on the BP signal.

A secondary circuit (U62, U55A) is used to sense and condition BP2 signal. The BP2 xducer has a range of -3 to 7 psi with an output voltage range of 0-+5V. To bring the output voltage of this xducer within the input range of the A/D converter, it needs to attenuate the voltage by a factor of .4.

#### HELIUM SENSE CIRCUIT

U60 generates a +5V excitation for driving the Helium transducer. Then the signal from helium transducer is filtered, and is the input to the A/D converter.

#### BALLOON CONNECTOR

U64 is used to generate a .5 ma current for the balloon connector resistor. The balloon connector voltage is equal to the .5 ma multiplied by the connector's resistance.

#### BATTERY AND 12V SENSE CIRCUITS

U54B is used to attenuate and filter the battery voltage. The battery voltage is connected to one of analog inputs of the serial A/D converter.

A voltage divider (R220, R223) and U57A are used to monitor the 12V power supply.

#### DIGITAL SIGNAL PROCESSING CIRCUIT

The heart of Front End Board's digital signal processing consists of a 68332 microcontroller which handles A/D conversion, digital filtering, pacer rejection, 4 ms tick for scheduler, and communication to the CPU.

The 68332-microcontroller TPU ports are used as I/O signals. The input signals are used to detect various states such as lead fault, pacer detection, or 4/5 lead detection.

## **5. Theory of Operation**

### **5.2: Functional Description Board Level**

---

The received data from low level ECG, and low level AP are converted to analog by D/A converter (U50). Every 4 ms the processor (68332) will send filtered ECG, and AP data to D/A converter through SPI link.

The low-level ECG signal is sampled at 250 HZ. A FIR digital filter later filters the sampled data. The filtered ECG signal will be transferred to the CPU, and D/A converter.

The low-level AP signal will be sampled at the rate of 250 HZ. The timing for the conversion cycle is the same as low level ECG. The AP signal does not require any more digital filtering. It will be transferred to CPU and D/A through SPI link.

The other analog signals such as High level ECG, AP, BP and etc. are multiplexed and converted by a 12-bit serial A/D converter (U46). Most of these signals are already filtered and do not require any more filtering, except BP signal.

#### **TIMING OF DSP CIRCUIT**

The main function of 68332 microcontroller is to generate signals for A/D converters, do digital signal processing, pack the data and send it to the CPU through a serial link. The 68332 microcontroller serial link to the A/D output is achieved by utilizing the SPI port. To convert the digital ECG, and AP to analog; two 12-bit data packets are transmitted to the D/A every 4 ms.

#### **POWER SUPPLIES ON FEB**

The power to the FEB comes from J6 connector (+12, -12 and +5V). The +12 volts supply is converted to +/- Viso1, and +/-Viso2 by means of a three terminal isolated power supply (BB 722). These are the isolated powers to the Low level ECG and AP circuits.

A +5 volt voltage regulator REF02 (U60) generates the reference voltage for Balloon Pressure and Helium transducer.

### LOW LEVEL ECG AMPLIFIER

The isolated low level ECG circuit is designed to amplify, filter, and electrically isolate the ECG signal detected by ECG electrodes. It is also designed to detect and reject the pacer signals, which could dominate the amplifier and display range.

#### LEAD CONFIGURATION (4 / 5 LEAD)

The Front End Board is capable of working with either 4 or 5-lead ECG cable. It automatically detects the cable type, and sends a flag to CPU indicating the cable type.

#### 4 LEAD CONFIGURATION

ECG LEADS	SELECTED SIGNALS
LEAD I	LA - RA
LEAD II	LL-RA
LEAD III	LL-LA

#### 5 LEAD CONFIGURATION

ECG LEADS	SELECTED SIGNALS
LEAD I	LA - RA
LEAD II	LL-RA
LEAD III	LL-LA
V LEAD	C - (RA + LA + LL)/3

#### GAIN ADJUSTMENT

The low-level ECG gain and offset can be adjusted for accuracy.

#### INPUT DYNAMIC RANGE

Input signal range	+/- 5mV MAX.
Input impedance	2.5 Megohms. min. @ 10 HZ
DC offset	+/-300 mV MAX.

#### FREQUENCY RANGE

Bandwidth	0.75 to 25 HZ (-3 dB)
Gain	400
Input To Output Delay	25 ms MAX

#### ELECTRICAL SAFETY SPECIFICATION

Isolation	2500V RMS for 1 min.
Leakage current	10 micro-amp MAX.
Common mode rejection	-80 dB Min. @ 60 HZ

## 5. Theory of Operation

### 5.2: Functional Description Board Level

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#### PACER DETECTION & PACER REJECTION

Pacer detection	Pulse width of .1 to .5 ms, 5 mV or greater Pulse width of .5 to 2 ms, 2 mV or greater
Pacer rejection	Pulse width of .1 to .5 ms, 5 mV or greater Pulse width of .5 to 2 ms, 2 mV or greater

#### LOW LEVEL AP

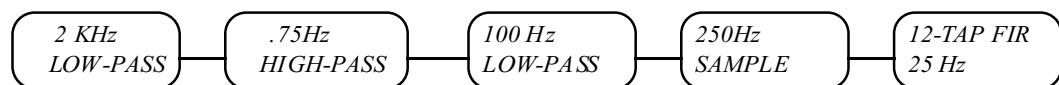
Input	50 micro Volts/Cm-hg/Volts
Gain	1V/100 mm-hg
Bandwidth	0 to 25 HZ
Isolation	2500V RMS for 1 min.

#### HIGH LEVEL SIGNALS

SIGNAL	GAIN	BANDWIDTH
BP1	12.4 (.4V/100 mm-hg)	0 to 25 Hz
BP2	.4V/V	0 to 25 Hz
Battery sense	.12V/V	5 HZ
Helium sense	.4V/V	5 Hz
High level ECG	2V/6V	50 HZ
High level AP	2V/6V	50 HZ
ECG out	500 mV/mV	0.75 to 25 HZ
BP output	1V/100 mmhg	0 to 25 HZ

#### LOW LEVEL ECG SIGNAL

Low level ECG leads (I, II, III, V) are sampled at the rate of 250 kHz. The digital filter is a 12-tap FIR filter. Following is the block diagram of the filtering on each ECG lead.



The 250 Hz sampled ECG goes through a 12-tap low-pass FIR filter with a 3db cut-off frequency of around 25Hz. This filter will filter any 50 or 60Hz signal present on ECG.

### FOS PCB (AutoCAT™2 WAVE only)

The AutoCAT™2 WAVE IABP has an internally mounted fiber optics pcb. This pcb works in conjunction with Arrow IAB catheters with the Light WAVE fiber optic arterial pressure sensor. These catheters have a fiber optic arterial pressure sensor mounted in the tip of the catheter.

When this catheter is used, the FOS pcb in the AutoCAT™2 WAVE sends an optical signal through a fiber optic wire in the IAB catheter to the sensor at the tip of the catheter. The optical signal is reflected by the sensor, back down the fiber optic wire to the FOS pcb. The frequency of the reflected optical signal is altered by the amount of pressure that is present on the sensor at the tip of the catheter. The FOS pcb converts the reflected optical signal to an electronic signal of a corresponding value, which is then sent out through connector J5 to the Front End pcb for further processing. Through this process, the pressure value present at the tip of the IAB catheter can be determined. The FOS board is powered by 12 volts from the front end BD and is delivered to the FOS pcb through connector J2.

To function properly, the fiber optic receiver on the FOS pcb must warm up to its desired operating temperature. To minimize the warm up time, the receiver has a heater to allow it to reach its operating temperature quickly. To keep the receiver from becoming too warm, a cooling fan, which is ducted to outside air, will circulate air around the receiver. A thermistor mounted on the receiver controls the operation of the cooling fan.

Each sensor also has its own unique performance characteristics. These performance characteristics are programmed on to a memory chip called a calibration key. A unique cal key is provided with each catheter and must be connected to the AutoCAT™2 WAVE when the catheter and sensor are connected. The information contained in the cal key is downloaded into the FOS pcb through J3. This calibration information is used to insure the accuracy of the pressure reading from that specific sensor.

In order to keep the FOS bd ready for use, the FOS bd is kept powered up at times when the power switch is off. This is accomplished by way of circuitry on the Front End bd, which is the source of power for the FOS bd. The logic for this circuit functions as follows. The FOS bd is always operating when the system is powered on. When the system is powered off, the FOS bd will always be operating if the system is connected to AC power. If the system is not connected to AC power, the FOS bd will be kept operating for a period of 4 hours after the system is powered off.

## 5. Theory of Operation

### 5.2: Functional Description Board Level

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If the SHOW STATUS key is pressed, the last line of the status screen displayed on the LCD of the systems contains information relative to the readiness of the FOS function. One or more of the following codes will be displayed.

No COM	No Communication	There is a communication error between the FOS bd and the system. This generally indicates a fault condition with the FOS circuitry that may require corrective action.
LL	Low Light	The level of light is less than expected. Performing the FOS cleaning procedure described in Sec 6.1 may correct this condition. If cleaning does not correct this condition, corrective action may be required.
SL	Strong Light	The level of light is greater than expected.
CK	Cal Key	The calibration key for the FOS sensor is not installed or is corrupt.
TL	Temperature Limit	The temperature of the optics assembly is outside of the acceptable limits.
BL	Barometric Limit	The barometric pressure is outside of the acceptable limits.
RE	Ratiometric Error	Internal A/D error within the FOS bd.
PL	Pressure Limit	The pressure measurement detected by the FOS sensor is outside of the acceptable limits.
IE	Instrument Error	FOS eprom checksum error is detected.
EO	Excessive Offset	Excessive offset condition exists between the factory setting and the actual barometric pressure reading.
LT	Loading Table	The system is loading the factory set lookup table.
SZ	Sensor Zeroing	The FOS sensor is performing a zeroing function.
RS	RS 232 Error	An error is detected in the RS 232 communication.
ST	Self Test	The FOS system is performing a self test.
FOS OK	FOS OK	The FOS system is functioning normally.

### **Stepper Motor Driver**

The stepper motor driver used in the AutoCAT™2 is a self contained module mounted above the pumping mechanism. It operates from the 54 volt circuit of the main power supply. An external capacitor mounted on the top of the stepper motor driver provides reserve energy for the surge current that occurs each time the stepper motor is put into motion. The stepper motor driver has the ability to operate in full step, half step and micro-stepping modes. Half step mode is used in the AutoCAT™2.

The stepper motor driver receives logic signals from the microcontroller on the CPU PCB and translates them into motor commands (i.e. step, direction). The execution of these commands results in the mechanical action of the stepper motor which drives the helium gas to and from the balloon.

The drive current which is applied to motor windings is controlled by the stepper motor driver .

### **Recorder**

#### *GENERAL SCANNING RECORDER*

The GS recorder is a compact light weight thermal array recorder that can print anything; graphics, text and waveforms using plain 50 mm wide roll of thermal paper.

It operates from 5V and 12V (via the CPU board and derives its's operational functions from the CPU board as well.

### **Home Sensor**

The Home Senor board is used to detect if the stepping motor is in the home position.

The board consists of a H21A2 photocoupled interrupter module (Q1) and a 74LS132 quad-2 input schmidt trigger positive nand gate (Z1).

The H21A2 is an infrared emitting diode coupled to a silicon phototransistor in a plastic housing. The gap in the housing provides a means of interrupting the signal, switching the output from an “On” into an “Off” state.

Q1 is driven by +5 volts across R1 turning on the phototransistor. When the phototransistor is turned on, +5 volts across R2 is shunted to ground providing a logic 0 at Z1 - pins 4 and 5 and outputting a logic 0 to the CPU board via Z1 - pin 8 (NHOME).

When Q1 is interrupted, the +5 volts across R2 is applied to Z1 - pins 4 and 5 providing a logic 1 at this point and outputting a logic to the CPU board.

This 1 to 0 transition of the Home Sensor is provided to the microcontroller (V34) on the CPU via J5.

## **5. Theory of Operation**

### **5.2: Functional Description Board Level**

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#### **Control Module**

The control module of the AutoCAT™2 consists of an LCD display and a keypad with integrated circuitry and LEDs connected to the AutoCAT™2 by way of a connecting cable called the umbilical cord.

The Theory of Operation for the keyboard controller describes the details of the circuitry contained in the control module.

#### **Keyboard Controller**

The keyboard controller assembly is a user interface module that can accept key activation as an input, or light LEDs (indicating the status of selected functions) as an output. It is also used to route the display signals to the LCD.

#### **DISPLAY INTERFACE**

Two AM26LS32AM differential receivers are utilized to receive the video signals transmitted by the CPU through the umbilical cord. These receivers convert differential signals to a TTL level logic signals. The video signals, after conversion, will be connected to the display driver through connector JP3 (34 pin connector). JP5 provides +12V power to the back-light of display module.

#### **KEY AND LED CONTROLLER**

The keyboard controller utilizes an 87C52 microprocessor which interfaces with the CPU through an RS232 link, scans the keys, and lights the LED's . This microprocessor contains built-in internal PROM, RAM, and two timer/counters.

A power monitor IC (U8), and an RS232 driver (MAX232) are utilized for reset generation and serial link communication.

An 8-channel source driver (UDN-2585A) in conjunction with a 220 ohm resistor pack are used to drive the LED anodes. The LED's are periodically driven through port 2 of the 87C52 microprocessor.

A ULN-2003L driver chip is utilized to drive the LED cathodes and the keys. Port 1 of the 87C52 is programmed to scan the KEY column periodically.

## Modem PCB

The AutoCAT™2 IABP has an internally mounted modem pcb that is used to allow the IABP to communicate with a pc over a standard analog telephone line. The pc must initiate the call to the telephone number of the line that is connected to the IABP. Upon receipt of the incoming call, the modem pc in the IABP will go off hook to answer the incoming call. Negotiations then begin between the modem of the IABP and the modem of the pc in order to establish communication. Once communication is established, data transfer will begin. Note that for safety reasons, data is only allowed to be sent from the IABP to the pc, it is not permitted for the pc to send data to the IABP that could affect the operation of the pc.

With an established connection, the display screen of the pc will appear similar to that of the IABP. Scrolling waveforms in the appropriate colors should be seen along with additional information such as trigger mode, battery status, ECG lead, operator key presses, etc. This information is taken from the main processing unit on the CPU pcb and sent via an RS232 serial link to the modem over connector P1 on the CPU pcb.

The modem operates on +5 volt from the power supply.

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The AutoCAT™2 Series IABP System requires minimal service and care. Routine maintenance procedures should be performed regularly to optimize performance and reduce the likelihood of down-time. When a specific operational problem occurs, the troubleshooting guidelines in Chapter 4 of the Service Manual will help you quickly diagnose and correct the problem.

Operators should attempt only those maintenance procedures described in this chapter, and you should be familiar with the functions and layout of the AutoCAT™2 Series (as described in Chapter 3) before attempting these procedures. Other service procedures should be performed by qualified Arrow International, Inc. technicians only. This chapter provides service and ordering information for your convenience. Arrow International, Inc. service organization operates 24 hours a day.

### **CAUTION**

Panel covers should not be removed by anyone other than Arrow International Field Service Engineers or their authorized representatives. Shock hazards exist when the protective covers are removed.

The contents of this chapter include:

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### **AutoCAT™2 Series System Maintenance Schedule**

This schedule provides an outline of the frequency that Arrow International recommends the following routine maintenance and service procedures be performed. The procedures listed as being in the Operator's Manual can be performed by the operator of the AutoCAT™2 Series, the Biomedical Engineering department, or other qualified personnel. The procedures listed as being in the Service Manual should only be performed by Arrow International Field Service Representatives or by trained Biomedical Engineering personnel.

<b>Manual</b>	<b>Section</b>	<b>Procedure/Frequency</b>	<b>Each Use</b>	<b>Weekly</b>	<b>Annually</b>
Operator	10.1	Condensate Removal	X		
Operator	10.1	Cleaning and Disinfection	X		
Operator	10.1	Operational Checkout		X	
Operator	10.1	Battery Test			X
Service	6.1	Battery Test			X
Service	6.1	Console Maintenance & Checkout			X
Service	6.1	Electrical Safety Test			X
Service	6.1	Preventative Maintenance			X

### **Hydraulic Load Simulator**

The Hydraulic Load simulator is recommended for use during servicing to simulate an IAB in a patient. Two versions of the hydraulic load simulator exist. The original version (IAT-00012), and it's replacement (IAT-00030). Although the two versions are similar in design and function, the operation of each is slightly different. Either device can be used for maintenance of the IABP, but the newer version provides higher accuracy for volume measurements. The information provided below outlines to the proper use and care of each simulator.

#### *IAT-00012 Operating Instructions*

1. Add water to the simulator until the water is at the level with the zero mark of the scale on the vertical glass column. The water can be added by removing the black rubber tubing from the fitting at the top of the column and injecting the water slowly through a syringe, or by removing the gauge from the top of the column and adding water through the opening. Please note that the screw in fitting on the gauge is fitted with Teflon tape to provide an airtight seal. This tape will need to be replaced when reinstalling the gauge to maintain an airtight seal.
2. Pressurize the simulator to the desired pressure by squeezing the hand bulb attached to the top of the unit. The proper backpressure for testing the AutoCAT™2 Series is 92 mmHg.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

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#### **IAT-00030 Operating Instructions**

1. Attach the glass tube to the base by sliding it onto its mount so that the o-ring seal the bottom of the tube. The "zero" end of the tube should be down.
2. Add water to the opening in the top of the tube until the water level reaches the zero mark on the tube.
3. Attach the rubber stopper to the top of the tube.
4. Apply desired pressure to the water column by squeezing the hand bulb connected to the top of the tube. The proper backpressure for testing the AutoCAT™2 Series is 92 mmHg.

For either simulator, attach the ARROW balloon connector to the IABP that is to be tested. When pumping the IABP, the water in the column should rise during inflation. The level that it rises to (as read on the scale of the glass tube on the simulator) should be approximately equal to the inflation volume selected on the IABP. This reading will vary slightly depending upon exactly how much pressure has been applied to the simulator.

#### **Maintenance**

These simulators require no special maintenance. It is recommended that the gauges be kept calibrated. Care should be taken to avoid harsh physical handling that could damage the simulator or cause leaks.

#### **Operational Checkout**

Arrow International recommends that you perform the Operational Checkout described below at weekly intervals to verify that the display, pumping mechanism, controls and indicators are functioning properly. The system should also be checked prior to its anticipated use to allow sufficient time to correct any problem found.

If the AutoCAT™2 does not respond according to the guidelines below, repeat the steps to insure that you have performed them correctly. If the faulty response continues, an operational problem could exist. Any problem encountered must be corrected. After correcting a problem, the Operational Checkout Procedure must be repeated. If you require assistance, contact your Arrow International service representative.

1. Plug the power cord into a properly grounded, active AC outlet.

The POWER INDICATOR LED on the front panel should illuminate.

#### **WARNING**

An electric shock hazard exists with this system. Always operate the AutoCAT™2 from a 3-wire hospital grade electrical system with a separate ground. Do not remove the grounding pin from the system's plug.

Do not use a 3-wire to 2-wire adapter to avoid the system's ground.

The biomedical engineering department or other qualified person should verify the integrity of the AC power system ground. In addition, the ground should be checked periodically.

A fully charged battery will power the AutoCAT™2 for approximately 90 minutes (180 minutes with an optional second battery installed). To fully recharge a completely discharged battery requires approximately eight hours. 80% of the battery's charge will be restored in approximately four hours.

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

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2. Power up the AutoCAT™2 using the power switch on the front panel.

The power switch LED, the LCD and the keypad LEDs for the preset parameters should illuminate.

3. Press the HOME key, then the SHOW STATS key. The statistics window should now be displayed on the AutoCAT™2 LCD.

Observe that the status of the POWER. It should indicate that the system is CHARGING.

If the status of the POWER indicates ON BATTERY, the AutoCAT™2 may not be receiving AC power. Confirm that the AutoCAT™2 is connected to a properly grounded, active AC outlet.

4. Check to make sure there is sufficient paper in the recorder. Print approximately five seconds of data on the recorder.

Observe the recorder strip to see that the selected waveforms were printed and that the printed parameters are the same as those selected on the AutoCAT™2 control module. Verify that the date and time are accurate, correct if necessary.

5. Check the helium supply reading on the AutoCAT™2 LCD.

It should read at least 100 psi. If the display shows less than 100 psi the helium tank should be replaced with a full tank.

6. Observe the helium reading on the LCD and confirm that there are no rapid drops or variations in the reading.

Any rapid drops or variations could indicate a leak in the helium supply circuit.

7. Select Internal Trigger mode.

Select Operator mode, then press Trigger Key

A message indicating that the AutoCAT™2 is in Internal Trigger Mode will appear on the LCD. The heart rate will be 80 BPM.

There are several indications that a trigger is present. These include a flashing heart in the upper right corner of the LCD, a flashing LED on the key of the selected trigger mode, and the presence of white bands on the top (green) waveform of the LCD.

8. Adjust the inflation and deflation timing settings using the keys on the AutoCAT™2 keypad.

Observe that the following items on the AutoCAT™2 LCD are changing: the timing bar at the bottom of the LCD, the white overlay on the green waveform.

9. Connect an load simulator to the balloon connection port of the AutoCAT™2. (This simulator does not come with an AutoCAT™2. It can be ordered as an accessory, see Sec 6.2 for ordering information.)

The volume of the balloon connector should be displayed on the LCD.

10. Press the PUMP STNDBY key to purge the system.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

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11. Press the PUMP ON key to initiate pumping.  
A balloon pressure waveform should be seen in the third channel of the LCD.
12. Press the FREEZE key to stop the display from scrolling. Press the FREEZE key again to resume scrolling of the waveforms.
13. Press the PUMP OFF key to stop pumping. Power down the AutoCAT™2 using the power switch on the front panel and disconnect the load simulator.
14. If the AutoCAT™2 will not be used within one month, follow the System Shutdown procedure instructions in this Section.

### **Cleaning and Disinfection**

Clean the AutoCAT™2 console, accessories and cables after each use.

#### **CAUTION**

**Do not clean the AutoCAT™2 Series while it is connected to a patient.**

1. Turn off the power and unplug the AutoCAT™2's power cord.
2. Use a soft cloth dampened with mild soap and water or 70% isopropyl alcohol to remove dust and dirt from the exterior of the console. To disinfect the console, use a 70% solution of carbolic acid (Lysol®<sup>1</sup>), methyl alcohol or isopropyl alcohol.

#### **CAUTION**

Clean and disinfect using only those solvents listed. **Do not** use other solvents. Avoid acetone, 100% phenol cleaners, ether or higher concentrations of formaldehyde. These chemicals can damage the console's finish and accessories.

3. Clean and disinfect accessories after each use according to the manufacturer's instructions. Cold-soak accessories in zephiran chloride. Soak blood-stained cables in hydrogen peroxide or a bleach solution for a few minutes.

#### **CAUTION**

Examine the cable's outer casing carefully for perforations before cleaning. **Do not** soak a perforated cable. Have it replaced immediately.

#### **CAUTION**

**Do not** submerge electrical connectors during disinfection. Secure a 0.3mm-thick polyethylene wrapping over the connector before cleaning.

**Do not** use phenol-based cleaners. They cause cables to harden and crack. **Do not** allow cables to remain immersed in alcohol or other cleaning agents.

#### **CAUTION**

Visually inspect all cables and accessories including the ECG, AP transducer/cable and power cord. If visible defects are present, replace the cable or accessory. If a visible defect is present in the power cord, **DO NOT USE IN AC MODE**. Replace the power cord. Operate in Battery mode **ONLY** until the power cord is replaced.

<sup>1</sup> Lysol® is a registered trademark of Lehn & Finks Products.

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

4. Clean patient cables and leads with a bactericidal agent or alcohol. Dry them thoroughly.
5. Plug the power cord back into an active, properly grounded AC power source.
6. Dispose of IABP accessories in compliance with government regulations and/or hospital regulations. Contact Arrow International for questions regarding disposal of specific IABP accessories or pump systems.

#### Condensate Removal

Check the condensate bottle with every use and empty whenever it becomes full. This can be done while pumping. Follow handling procedures for biohazardous waste removal.

1. Open the helium compartment to find the condensate bottle (behind the He tank in the recess).
2. Lift the black locking handle to the left of the He tank, then pull the bottom of the He canister toward you.
3. Pull out the bottle (keeping it upright) and unscrew the cap.
4. Empty the bottle. Follow bio-hazardous material handling procedures for your hospital.
5. Screw on the cap, replace the bottle and close the compartment.



Figure 6.1: The Condensate Collection Bottle



Figure 6.2: The Condensate Collection Bottle  
Behind the Helium Tank

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

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#### Recorder Paper Installation

The recorder uses rolls of blank 50mm thermal-sensitive paper. See Section 6.3 for ordering information.

1. Verify that the strip chart recorder is off.
2. Follow the paper loading instructions listed below.
  - Push the latch at the top of the recorder to open paper compartment. Gently remove the old roll.
  - Place the new roll of recorder paper in the compartment. The paper should feed out from under the bottom of the roll. Feed some paper out towards the front across the rubber roller.
  - Close the door.

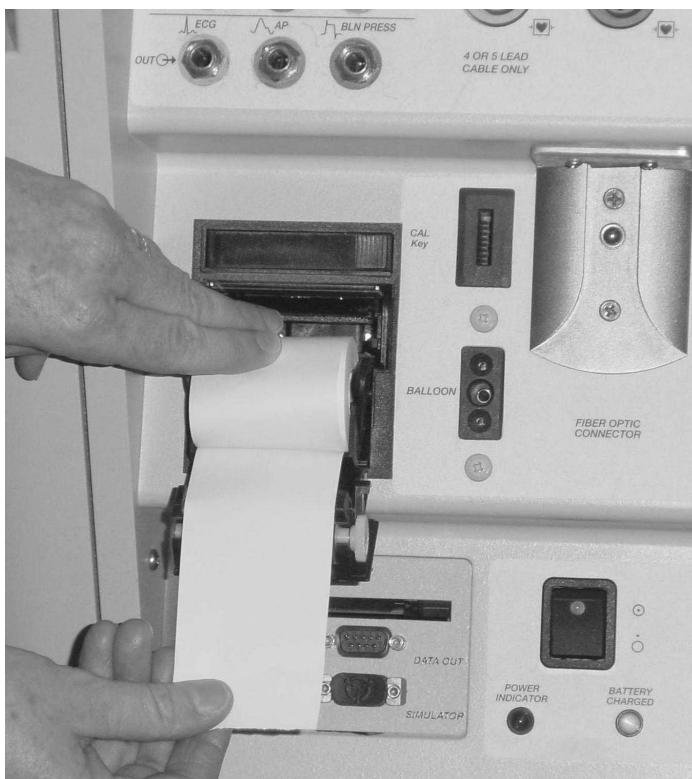


Figure 6.3: Strip Chart Recorder

3. Press the ON/OFF control key to obtain a recording. You should see lines and print on the paper. Press the ON/OFF control key again to stop recording.

**Note:** If waveforms are not printed, the paper has been inserted backwards.  
Repeat step 2, reversing the direction of the paper roll.

**CAUTION**

High pressure gas canisters should be handled by trained personnel only.

## Helium Tank Replacement

The helium tank should be replaced when “LOW HELIUM SUPPLY” appears on the LCD (the helium supply has fallen to 100psi). Use only 500psi disposable or 2000 psi disposable/refillable USP helium canisters. See Section 6.3 for ordering information.

*Note: The AutoCAT™2 provides automatic scaling of the He bar graph, depending on the amount of He in the tank.*

*When the He level is above 500 psi the display scale will be 2000 psi. Each division is 500 psi. When the tank pressure is below 500 psi the bar graph will rescale to 500 psi. The 500 value will be displayed in yellow to indicate a different scale. Each division is 125 mmHg. The bar graph changes to red when the He level is less than 125 mmHg the bar graph will go to black when less than 20 psi are in the tank. The tank should be changed when the bar is in red.*

*Press HOME and SHOW STATS to view the He tank pressure in psi.*

1. If the AutoCAT™2 is in use, press the OFF control key in the ALARMS section of the keypad and select the F1 key for 10 minutes off. This will temporarily disengage the automatic refill system. After completing the tank replacement procedure, press the ON control key in the ALARMS section of the keypad to re-engage the automatic refill system.
2. Open helium compartment door.
3. Identify tank.

### 500 psi disposable tank -

- a. Lift latch.
- b. Pull bottom of tank toward you.
- c. Unscrew tank and dispose

*Note: If 2000 psi tank will be installed, remove 500 psi tank yoke adapter (see Section 2.1 for details) then follow instructions for 2000 psi tank installation.*

- d. Screw in a new cylinder by inserting the He tank threads into the regulator adapter.
- e. Verify He tank pressure on display.
- f. Push the bottom of the He tank in and secure with the latch.
- g. Close helium compartment door.

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

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#### 2000 psi tank -

- a. Close tank valve on top of tank.
- b. Loosen T-handle on regulator yoke.
- c. Remove tank.
- d. Reinsert new 2000 psi tank (insure He washer is in place) and align tank to locating pins.
- e. Tighten T-handle.
- f. Open tank valve.

Note: If you desire to replace 2000 psi tank with 500 psi tank, the 500 psi regulator yoke adapter must be installed in the regulator yoke. Then follow the instructions for installing a 500 psi disposable tank.

- g. Close helium compartment door.

- h. Verify helium level.



Figure 6.4: Helium Tank Installation with Disposable Tank



Figure 6.5: Helium Tank Installation with Refillable Tank

## Fuse Replacement

The AutoCAT™2 has two fuses located in the pump module. These should be changed only by Arrow International Field Service Engineers or trained personnel. See Section 6.3 for ordering information.

### **CAUTION**

Use only the fuse type and rating specified. Call Arrow International's service number for assistance.

### **CAUTION**

Panel covers should not be removed by anyone other than Arrow International Field Service Engineers or their authorized representatives. Shock hazards exist when the protective covers are removed.

To change the fuses (if necessary), remove the AC power cord as described in Section 2.1, use a small flat blade screwdriver to press on the fuse holder locking lever and remove the fuse drawer which carries two fuses. Remove fuses from the drawer, insert new fuses into the drawer and install fuse drawer back into place. Press the drawer in until it clicks indicating that it has locked into position. Reinstall the power cord as described in Section 2.1.

## System Shutdown

If the AutoCAT™2 will be idle for four weeks or more, shut down the system as follows:

1. Press the power switch to turn off the power.
2. Remove the disposable helium tank or turn off disposable/refillable tank (see instructions in this section).
3. Empty the condensate bottle (see instructions in this section).
4. Store all required cables with the console.

**Note:** *Leave the power cord connected to an AC power supply to maintain a full charge on the battery. The system automatically prevents overcharging.*

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

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## **Service Trained Personnel Only**

### **Sealed Lead Acid Battery Maintenance**

The AutoCAT™2 System utilizes one, or two with optional second battery installed, sealed lead acid batteries to power the system during times when AC power is not available. The batteries are considered maintenance free, meaning that they are sealed to prevent leakage and they do not require the operator to add any materials such as water or electrolyte. However, routine care of these batteries should be taken to insure their safe operation and maximize their usable lifespan. The following steps outline the basic procedures that should be followed for proper sealed lead acid battery care.

The batteries are labeled with the following information:

- Refer to the manual symbol “!”
- battery symbol
- recycling symbol
- Arrow part number for the battery
- lead contents in %
- disposition instructions

1. The battery should be maintained at full charge whenever possible. Arrow International recommends that the AutoCAT™2 IABP System be kept plugged into a proper AC receptacle whenever possible including time when the unit is in storage or not in use. The power indicator will illuminate when AC power is present. The batteries should not be stored in a discharged state.
2. If it is desired to clean the case of the batteries, use only a water dampened cloth. Solvents such as paint thinners, adhesive removers, and petroleum based materials should never be used. The case of the batteries is constructed of high impact ABS plastic resin and could be damaged by such solvents.
3. Visually inspect the batteries for signs of physical damage such as leaks or cracks in the case. Any physically damaged batteries should be replaced immediately. Never attempt to repair or dismantle any battery. If there is accidental body contact with battery electrolyte, flush the contacted area with liberal amounts of clean fresh water and seek medical attention.
4. Never short circuit the terminals of the battery.
5. The AutoCAT™2 IABP System has an automatic battery voltage level monitor which shuts down the system should the voltage fall below 10 volts. Discharging the batteries below 10 volts will provide very little additional running time of the AutoCAT™2 IABP System and could possibly damage the batteries. The batteries should not be discharged below this level.

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

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6. Heat is detrimental to batteries. Batteries should always be stored away from sources of heat whether in the unit or outside. The batteries contain a safety vent which is designed to release gasses if the temperature of the batteries exceeds 125 degrees Fahrenheit. If the vent has been actuated the batteries should be replaced.
7. With proper care, the batteries used by the AutoCAT™2 IABP System should provide many years of trouble free service. It is not required that these batteries be replaced based solely on the basis of their age. As the batteries age, it is important that their performance be periodically checked to insure that they will perform as intended. It is recommended that a load test be performed by qualified service personnel at six month intervals to ensure battery capacity and usability. Any time that the batteries do not pass the load test they must be replaced.

If it is not possible to perform the load test, or if the batteries' capacity and usability cannot be verified for any reason, the batteries should be replaced after three years of use.

8. If the optional second battery is installed and replacement of the batteries is required for any reason, always replace the batteries in pairs and with the proper type and rating of battery and follow battery replacement procedure outlined in this manual. Never replace only one battery.
9. Sealed lead acid batteries are manufactured of highly recyclable materials and should be recycled whenever possible. Never dispose of batteries in fire. Doing so could result in possible rupture or explosion of battery. **For lead acid battery disposition instructions contact your local Government Authorities or Arrow International local representative.**

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

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#### **Battery Load Test**

1. Plug the AutoCAT™2 System into a proper AC outlet for at least four hours to charge the system's internal batteries.
2. After fully charging the system's internal batteries, measure the battery voltage at the battery terminals. The battery voltage should be 13 volts DC±0.1 volts to perform this test. If the battery voltage is below this level, the internal batteries are not fully charged. Allow additional charging time before beginning this test. Repeat step 1. After the additional charging time has passed, measure the battery voltage again. If the battery voltage is at least 13 volts DC±0.1 volts, proceed to step 3. If the battery voltage is still not at this level, after two battery charging cycles, a possible problem may exist in the charging/battery system. Power down the AutoCAT™2 and notify qualified service personnel.
3. Attach an Arrow Hydraulic Load Simulator or other proper load device to the balloon connector of the AutoCAT™2. Install a helium cylinder with at least 100 psi of pressure. Select INTERNAL TRIGGER by pressing the INTERNAL TRIGGER key twice. Press PUMP ON to initiate pumping. Disconnect the AutoCAT™2 from AC power by removing the AC plug from the wall receptacle.
4. After a few seconds an alarm indicating that the AutoCAT™2 System is now running on battery power will be activated. Reset this alarm by depressing the RESET key in the alarms section of the keypad.
5. Make note of the time and the battery voltage.
6. Allow the AutoCAT™2 to operate in this condition for 90 minutes. If the AutoCAT™2 is still operating after 90 minutes, the battery is meeting its operating specification. If the AutoCAT™2 has shutdown before 90 minutes of operation was achieved, the battery is not providing full capacity and should be replaced.
7. Press PUMP OFF and power down the AutoCAT™2. Restore AC power by connecting the AC plug of the AutoCAT™2 to a proper AC receptacle. Allow the system to recharge the batteries for at least four hours.

**Note:** *It is not necessary to power down the AutoCAT™2 System in order to charge the batteries. Proper charging will take place whether the AutoCAT™2 is powered up or powered down as long as the system's AC plug is connected to a proper AC outlet.*

**Note:** *If the AutoCAT™2 has the optional battery, the operation time should be 180 minutes instead of 90 minutes. If 180 minutes is not achieved with two batteries, both batteries should be replaced.*

### **Battery Replacement Procedure**

1. Switch the IABP off using the front panel power switch.
2. Switch off the DC circuit breaker and remove AC power from the unit by unplugging it from the wall outlet.
3. Remove the right side cover of the unit by pulling down on the two retaining clips under the bottom edge of the panel. Lift the side cover off of the AutoCAT™2.
4. On the right side of the unit, disconnect the two quick-disconnect plugs for the batteries, one for the positive lead and one for the negative lead.
5. Remove the two screws holding the front edge of the battery retaining bracket to the bottom panel of the unit's base.
6. Lift the front edge of the battery retaining bracket and remove the battery bracket.
7. Lift the battery out and remove it. Exercise caution to ensure that the battery's positive and negative leads do not touch any part of the unit while pulling the battery out.
8. Transfer the positive and negative power leads from the battery that was removed to the battery that is about to be installed. Be certain to connect the proper color wire to the proper battery terminal lead. The BLACK lead to the NEGATIVE terminal of the battery and the RED lead to the POSITIVE lead of the battery.
9. Install the battery into the left side of the unit. It should be installed in the same manner as the battery which was removed.
10. Secure the battery retaining bracket by reinstalling the two screws.
11. Connect the two quick-disconnect plugs for the batteries, one for the positive lead and one for the negative lead. All quick connect plugs are labeled with either the "+" or "-" symbol. ALWAYS CONNECT "+" to "+" and "-" to "-".
12. Plug the AC connector into a proper AC wall outlet.
13. Switch on the DC circuit breaker.
14. Power on the AutoCAT™2 and measure the battery voltage at the battery. The battery voltage at this point should be between 10 and 14 volts DC. This voltage will vary dependent upon the state of charge of the newly installed batteries. If the batteries are not fully charged the voltage will be lower than 14 volts DC but the voltage should be slowly rising. If the batteries are fully charged the voltage should be at approximately 14 volts. It is recommended that after installing new batteries that the AutoCAT™2 be plugged into a proper AC outlet for at least four hours to charge the batteries.
15. Reinstall the side cover of the unit.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

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#### **Console Maintenance And Checkout Procedure**

The following procedure should only be carried out by an Arrow International service representative or by trained Biomedical Engineering personnel in accordance with a schedule established via service agreement or by hospital policy.

##### **General Cleaning and Inspection**

1. Perform any outstanding Field Change Notices (FCN) on the console.
2. Remove the right side cover.
3. Inspect the interior of the AutoCAT™2.
  - Vacuum any accumulated dust.
  - Check tubing for any discoloration, cuts or punctures. Replace as necessary.
  - Check for any loose hardware or cables. Tighten or replace as necessary.
4. Check all controls and switches for proper operation.
5. Check power supply voltages to insure they are within specifications.
6. Check stepper motor controller drive current to insure that it is within specification.
7. Check balloon pressure transducer to insure that it is within specification.
8. Perform a battery load test to test the capacity of the battery.
9. Perform the functional test procedure to insure proper operation of the AutoCAT™2.

### **Power Supply Checkout**

All outputs of the AutoCAT™2 power supply are fixed and there are no adjustments to be made. A checkout of the power supply involves simply measuring the regulated output voltages to insure that they are within their specifications, measuring the charging voltage for the battery, and checking for proper operation of the logic control signals to and from the power supply.

#### ***Output Voltages***

There are four output voltages are +5, +12, -12, and +54 used to power the AutoCAT™2. These voltages should be present when the power switch on the front panel of the AutoCAT™2 is ON and should not be present when the switch is OFF.

There are also two outputs for battery charging, a primary (labeled #1) and a secondary (labeled #2). If only one battery is installed it must be connected to the primary output connector. The outputs should be present at all times when the AutoCAT™2 is connected to AC power regardless of the condition front panel power switch.

The power supply's output voltages should be within the following ranges:

Circuit	Minimum Voltage	Maximum Voltage	Measured At
+5 volt	+4.75	+5.25	C81 on CPU bd.
+12 volt	+11.8	+13.2	C82 on CPU bd.
-12 volt	-11.8	-13.2	Pin 6 (Blue Wire) of Front End Shield Power Connector
+54 volt	+50	+57	Capacitor on stepper motor controller
#1 battery charger output	+13.4	+14.2	#1 output and ground
#2 battery charger output	+13.4	+14.2	#2 output and ground

**Note:** When measuring the battery charger outputs the batteries should be fully charged or disconnected. If a discharged battery is connected at the time the measurements are taken, the readings obtained will most likely be lower than the minimum voltage listed in the table.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

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#### **Logic Control Signals**

The logic control signals are used to:

- a. switch the power supply on/off via the switch on the front panel of the AutoCAT™2.
- b. illuminate the POWER INDICATOR LED on the front panel of the AutoCAT™2 when AC power is present.
- c. illuminate the BATTERY CHARGED LED on the front panel of the AutoCAT™2 when the battery is approximately 75% charged or greater.
- d. a circuit in the power supply monitors the +5 volt supply. If the output of the +5 volt supply falls to an unacceptable level, a logic line will be enabled which will activate a monotone sonalert. The monitoring circuit, and the sonalert beeper, operate independently on the +12 volt supply.

Logic control signals can be verified by confirming proper operation of the front panel power switch, it's LED indicator, the POWER INDICATOR LED, and the BATTERY CHARGED LED.

The power supply's internal cooling fan should operate:

- a. at all times if the AutoCAT™2 is connected to AC power, regardless of the condition of the front panel power switch.
- b. when the front panel power switch is ON if the AutoCAT™2 is not connected to AC power.

#### **Stepper Motor Controller Checkout**

The stepper motor controller accepts control signals from the CPU board and power from the power supply. It utilizes these two elements to drive the stepper motor.

The amount of current that is applied to the motor windings is controlled by the stepper motor controller. This is factory set and cannot be changed.

To confirm the stepper motor drive current, place the AutoCAT™2 in standby mode and measure the current in one of the leads that run to the stepper motor. The current should be approximately 4.25 amps.

#### **FOS PCB Checkout (AutoCAT™2 WAVE only)**

Note: In order to test the FOS function, a special test fixture is required. This fixture consists of an FOS sensor attached to a calibrated pressure source.

1. Power on the IABP.
2. Insure that the IABP has a valid trigger. If a valid trigger is active, a numeric heart rate will be displayed in the upper right corner of the LCD.
3. Connect the test fixture to the FOS connection on the IABP. Insure pressure source is vented to atmosphere and allow sensor to self zero.
4. Using the AP select key on the keypad of the IABP, select FOS as the pressure source. Verify that the pressure reads 0mm Hg on the IABP display.

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

5. Reading the pressure on the calibrated pressure source, apply pressure at the levels indicated in the table below.
6. At each of the referenced levels, the pressure level displayed on the right side of the LCD of the IABP will match that of the calibrated pressure source within 2%.

Pressure Applied by Calibrated Pressure Source	Minimum Acceptable Reading on IABP	Maximum Acceptable Reading on IABP
0mmHg	0mmHg	0mmHg
50mmHg	49mmHg	51mmHg
100mmHg	98mmHg	102mmHg
150mmHg	147mmHg	153mmHg
200mmHg	196mmHg	204mmHg
250mmHg	245mmHg	255mmHg

7. Remove the test fixture from the IABP.
8. Verify that the FOS cooling fan is operating properly. If the unit has been powered on for sufficient time and the thermistor is up to the temperature required to activate the fan, the cooling fan located under the air duct by the front left wheel will be operating. This can be verified by removing the tubing from the air shroud on the FOS pcb and feeling for airflow.

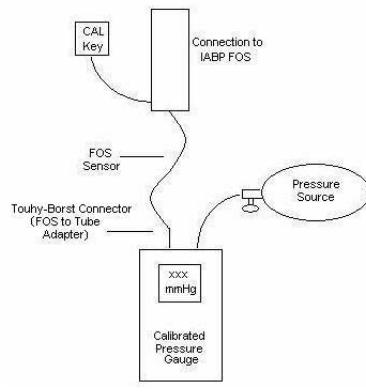
If the unit is not up to the temperature required by the thermistor to operate the fan, a heat source (such as a hair dryer or heat gun) can be used to slightly warm the thermistor. After warming the thermistor, the fan should switch on and air flow should be detected.

Note: The thermistor is the white rectangular component located in the center of the air shroud over the FOS pcb. Only slight warming is necessary. Extremely high heat that can be developed by some heat guns should be avoided. High powered heat gun should be used at a low setting and the gun should not be positioned too close to the pcb.

The ability of the optical connection to transmit the optical signal can be affected over time. Dust or dirt can gradually accumulate. Wear can also occur from repeated connecting and disconnecting of the FOS catheter. Each of these can cause the quality of the optical connection to be reduced. In order to maintain a high quality optical connection, the tip of the optics wire can be cleaned using an FOS cleaning kit available from Arrow International. The cleaning procedure can be performed as needed, when an indication of a weak FOS signal is observed. If the cleaning procedure cannot be performed, or does not correct the weak FOS signal condition, the FOS adapter may need to be replaced.

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures



FOS Test Fixture

### Balloon Pressure Transducer Checkout

There is no adjustment for the balloon pressure transducer. However, its linearity and offset should be checked to insure that it is within specification.

To check the balloon pressure transducer:

- a. connect a voltmeter to the balloon pressure output jack on the front panel of the AutoCAT™2 (+ to tip, - to sleeve).
- b. Switch the AutoCAT™2 ON.
- c. Take a reading of the initial offset voltage. It should be 0 volts  $\pm$  250mv.
- d. Place the AutoCAT™2 into the Standby mode.
- e. Connect a hand bulb and gauge to the balloon connector of the AutoCAT™2.
- f. Apply the pressures of 50, 100, 150, 200 and 250mmHg. Record the voltage at each pressure level.
- g. Subtract the offset voltage (from step c) from the values recorded at each pressure level. The results should be within the following ranges.

Applied Pressure	Minimum Voltage	Maximum Voltage
0mmHg	-250mv	+250mv
50mmHg	+475mv	+525mv
100mmHg	+950mv	+1.050v
150mmHg	+1.425v	+1.575v
200mmHg	+1.900v	+2.100v
250mmHg	+2.375v	+2.625v

- h. With a pressure of 250mmHg applied to the hand bulb and gauge, the balloon pressure waveform of the LCD should read 250mmHg  $\pm$  5%.

### **Preventative Maintenance Checkout**

Arrow International recommends that the AutoCAT™2 IABP series be serviced at regular intervals as outlined in the Maintenance Schedule at the beginning of this chapter. The PM Checklist at the end of this procedure is intended to serve as a guide to insure that no steps are missed while performing the procedure. It is recommended that when performing this procedure, a photocopy of this page be made, and each step be checked off as it is performed. If desired, the checklist can be retained as part of the paper record of the service of that unit.

Please note that other than the final steps of this procedure where it is indicated that the system must be in AutoPilot™ Mode, all other parts of this procedure should be performed with the unit in Operator Mode.

#### **Initial Inspection**

1. Clean and disinfect the exterior of the unit as needed. If needed, see details provided Section 6.1 Cleaning and Disinfection. Visually inspect the unit for any signs of damage or misuse.
2. Insure that the unit is complete with all accessories so that it is ready for use. Locate any accessories that may be missing. Check that there is a helium cylinder in place and paper in the recorder.
3. Determine the current FCN status of the unit by looking at the FCN Label located inside the helium compartment. Compare this with the most recent FCN information for that model (this can be verified by contacting Arrow International's technical support network). Install any applicable outstanding FCNs.

#### **Mechanical Integrity**

4. Check for any loose cables, hardware, connectors, etc both on the exterior of the machine and on the interior, once the side panel has been removed. Secure any item as needed.
5. Verify that the Water Collection Bottle (located behind the helium tank) is in place and empty it of any water that may have collected there. If needed, see details provided in Section 6.1 Condensate Removal.
6. Insure that no cables or tubing are routed in such a way that they could become kinked or cut. If any disassembly is performed, care should be taken during reassembly to be sure that all cables and tubing are routed in a proper manner where they would be safe from any possible harm.
7. Insure that the balloon interface connector is securely mounted to the front panel, and that the rotation latch locks the rotation of the column with minimal play.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

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#### **Check and Adjust as Required**

8. The Raise and Lower Mechanism of the display column should move up or down when the button on the handle is pressed in, and lock in place when the button is released. Pressing the button disengages a braking assembly inside the column allowing movement. Releasing the button engages the braking assembly, stopping the movement.

A cable attached to the back of the button runs down the column to the braking assembly. By way of a small screw on the end of the cable behind the button, the tension, or preload, on this cable can be adjusted. Too much tension causes the braking mechanism to be continuously disengaged, allowing the column to move up and down without the button being pressed. Too little tension continuously engages the braking mechanism, not allowing any up and down movement even when the button is pressed.

If properly adjusted, the column should move freely up and down when the button is pressed, and lock in place when the button is released. If adjustment is required, remove the display module from its base. Then separate the top and bottom halves of the display base / handle by removing the screws on its underside. Once separated, the top half of the base / handle can be removed, and the adjustment to the screw can be made.

9. The helium regulator is located on the pivot at the top of the helium tank. On the back side of the regulator (accessible with the right side cover removed), there is a small hex screw protruding slightly from the upper stage of the regulator. Adjustment of this screw will vary the output pressure from the regulator. The output pressure can be measured by removing the tubing coming off the regulator and attaching a pressure gauge. In order to access the adjustment screw, it is necessary to tilt the regulator slightly. This is accomplished by tilting the helium tank outwards. If needed, see details provided in Section 6.1 Helium Tank Replacement.

#### **Check and Verify**

10. Verify that the unit operates in both AC and DC mode. This can be done by first operating the unit with AC connected and the DC circuit breaker OFF. This should produce a Battery Inoperable Alarm. Reset the alarm and check off this alarm in the Alarm Simulation section of this procedure. Then switch the DC circuit breaker on and disconnect the AC. This should produce a System On Battery Alarm. Reset the alarm and check off this alarm in the Alarm Simulation section of this procedure. Also note the time the unit began operating on DC. Perform the remainder of this procedure with the unit operating in DC. The unit should operate for a minimum of 90 minutes on DC operation (assuming the batteries were fully charged to at the start). Allow the unit to operate for at least 90 minutes, or until the unit shuts down. Based on the time that the unit started DC operation, calculate the DC run time to complete the last step of this procedure (Battery Test).

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

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Note that due to the design of the AutoCAT™2 Series IABP, the current drawn by the unit is nearly constant regardless of the operating conditions. Therefore, the various operating conditions encountered during the completion of this procedure should not have an significant effect on the battery run time of the unit.

11. Measure the outputs of the Power Supply. If needed, see details provided in Section 6.1 Power Supply Checkout.
12. Measure the current being supplied to the stepper motor by the stepper motor driver. If needed, see details provided in Section 6.1 Stepper Motor Controller Checkout.
13. Verify that the recorder operates properly. Printing should be clear with sufficient contrast and intensity. Print speed can be verified by printing an ECG signal of 60 BPM. At that heart rate, a QRS should occur every fifth box of the chart.
14. Verify proper operation of the Balloon Pressure Transducer. If needed, see details provided in Section 6.1 Balloon Pressure Transducer Checkout.
15. Verify the RAM memory. The RAM memory is intended to retain operational settings of the unit, if the unit is powered down momentarily. This test can be accomplished changing some of the operational settings from their default values. For example, select Operator Mode and change to AP trigger with an assist ratio of 1:8. Power the unit off for approximately 10 seconds, then power the unit back on. If the RAM Memory is good, these settings will be retained and the unit will still be in Operator Mode with AP trigger and an assist ratio of 1:8.
16. Verify that he Cold Trap cooling element is active. This can be accomplished by touching the Cold Trap block at the point where the helium line attaches to it. It should feel cool to the touch. It is accessible in the lower front of the unit with the right side cover removed.
17. Verify that all three fans (front panel, cold trap, and power supply) are spinning and unobstructed.
18. Verify that the speaker and piezo beeper are functioning. Remove the balloon tubing while the unit is pumping. This will cause a Helium Loss alarm and the speaker to begin beeping. Do not reset the alarm. After 1 minute, the piezo will begin beeping. Press alarm reset and both indicators should stop beeping.
19. Verify the visual quality of the display. The waveforms and text should be clearly readable. Press each key. Confirm that each key press is recognized by the unit. Verify that the appropriate LED lights for key that have LEDs associated with them.
20. Verify that the date and time are properly set.
21. (This step for AutoCAT™2 Wave units only) Verify proper operation of the FOS pcb. If needed, see details provided in Section 6.1 FOS pcb Checkout.
22. The alarm board should produce a constant alarm tone if either the +5v or +12v supplies fail. To test the functioning of this circuit: a) Remove the AC power cord. b) Switch the DC circuit breaker off. c) Turn the power switch on. At this time a constant alarm tone should be audible. The duration of the tone may vary but it should last for a minimum of approximately 30 seconds.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

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#### **Helium Leak Test**

23. The helium Source Side leak test and Patient Side leak test can be done simultaneously. Initiate pumping on the unit in Internal Trigger at 80 BPM. Connect a balloon simulator that is known to be good (i.e. have no helium leaks). After 30 seconds, Press Alarms OFF and select 30 minutes. Turn off the valve on the top of the helium tank. Press Show Stats and note the helium tank pressure (for this test, a helium tank with a minimum of 300 psi should be installed). Also note the balloon baseline pressure (it is generally around 3 mmHg). The cursor may be used to make this measurement. Allow the unit to continue pumping under these conditions for 15 minutes.

Source Side – At the 15 minute mark, press the show status key and note the helium tank pressure again. It should not have dropped more than 1% (for example, if the helium tank pressure is 300psi, the maximum allowable drop in fifteen minutes would be 1psi). If it has, there is a helium leak in the system between the helium tank regulator and the PCS assembly. Locate the leak and correct it.

Patient Side – Also at the fifteen minute mark, note the balloon baseline pressure again. It should not have changed by more than 5 mmHg. If it has, there is a leak in the system between the PCS and the IAB connector. Locate the leak and correct it.

#### **ECG, AP, and Trigger**

24. Input the appropriate signals from a simulator and verify that the unit triggers from all trigger sources (all leads, hi-level, low-level, ECG, AP, Pacer, and Internal).

Verify that signals are present on the output jacks. For ECG, AP, and Balloon, the outputs may be slaved into a different phone jack input. For example, to check ECG output, first connect a low-level ECG signal from a simulator to the Green ECG skin connector and select ECG Skin as the ECG input. Then connect a phone-phone cable from the ECG phone jack output to the AP phone jack input. Select AP source to be Monitor. An ECG signal should now be seen on both the ECG channel and the AP channel of the LCD. Note that due to differences in scaling, the size of the waveform may be different. Similar steps can be followed to check the output of the AP or Balloon channels.

For the AP, connect a low level AP signal from a simulator to the orange AP input, then connect the AP output to the ECG input. Select ECG Monitor input and AP Transducer input.

For the Balloon output, connect a phone jack from the Balloon output to the ECG phone jack input. Start pumping so that a balloon pressure waveform can be seen on two channels of the LCD.

For Assist output, connect a phone-phone cable from the Assist output to the AP input and select AP Monitor input. A square wave should be seen on the AP channel of the LCD. The unit must be pumping for the Assist waveform to be present.

If using the Arrow International simulator PN IAT-00201 or IAT-00221, test functionality of the SIMULATOR I/O port on the IABP by connecting the simulator to the IABP using the 9 pin D cable.

### **Additional Checks**

25. Connect the unit to a direct dial analog telephone line to the unit (it is generally most convenient to momentarily utilize a line from a nearby fax machine for this test). Using a PC that has the Arrow IABP communication software installed, dial a connection to the IABP (it will be necessary for a second analog phone line to be connected to the modem of the pc also). Shortly after the connection is established, the IABP should begin transmitting data to the PC. A screen similar to that of the IABP's LCD should appear on the PC. Check some of the parameters to verify data is being accurately sent.
26. Install a flashcard into the IABP. Select some settings that are different than default. For example, the default trigger selection is Pattern. Change to VPACE. Change other settings from their default if desired. Press the Show Status key. Multi function key #1 will be labeled Save To Flash. Press this key. Follow the steps on the LCD to confirm. Power the unit off and wait ten seconds. Power the unit on. A message should appear indicating that Flashcard settings are in use. The trigger mode should be VPACE. Any other settings that were changed should also come up in the condition that they were saved as.
27. Connect a Hydraulic balloon simulator with a 50cc connector attached. Insure that there is sufficient water in the simulator to determine a volume reading. Also insure that the correct back pressure is applied. The proper backpressure for testing the AutoCAT™2 Series is 92 mmHg. Pump the unit and observe the volume being displaced on the simulator. It should be 50ccs +/- 10% (5ccs). Repeat the test using a 40cc setting, and a 30cc setting, on the IABP. In each case the displaced volume should be within 10% of the selected volume.
28. Pump the unit and observe the augmentation step on the Balloon Pressure Waveform. It will appear as a small notch in the waveform as the pressure returns up to zero after a deflation. The notch should occur at approximately -40mmHg. About 4 dotted lines below zero on the grid.
29. Power off the machine for ten seconds then switch Power on. Note the time. Twenty minutes after power on (and every twenty minutes thereafter), the system will perform a drain task provided that the system is pumping and that the alarms are not disabled. With the unit pumping, at the twenty minute mark carefully observe the balloon pressure waveform. A drain cycle should be seen. During a drain, the inflation plateau and the baseline pressure will drop slightly. This will immediately be followed by a refill function to recover any helium that is lost during the drain cycle. Some clicking of the solenoid valves may also be heard during the drain/refill cycle. Note: it is easier to observe a drain cycle at a lower heart rate. Select a heart rate of approximately 60 BPM for this test.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

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It is acceptable to proceed with the Preventative Maintenance procedure and perform some of the following Alarm simulation steps during the twenty minute wait time. Since the twenty minute drain counter is only reset by a power cycle, other operation of the IABP should not interfere. Be mindful of the time however and be ready to observe the drain when the time approaches. The system must be pumping at the time in order for the drain to occur.

#### **Simulate Select Alarm Conditions**

30. There are 4 classes of alarms. Each class will produce different responses by the IABP. Class 1 places the unit in Pump Off mode, prints a recorder strip, displays a message on the LCD, lights the Alarm Reset Key LED, and produces an audio tone. Class 2 places the unit in Standby Mode, displays a message on the LCD, lights the Alarm Reset Key LED, and produces an audio tone. Class 3 and Class 4 alarms display a message on the LCD, lights the Alarm Reset Key LED, and produces an audio tone. The following represents a sample of alarms from each class. Simulate the following alarms conditions and verify that the unit detects the conditions and the appropriate response is delivered.

#### **Class 4**

No ECG Available      \*Pump must be in AutoPilot™ Mode for this alarm\*

Connect an ECG and an AP signal to the unit and begin pumping. While pumping, remove the ECG signal.

No AP Available

\*Pump must be in AutoPilot™ Mode for this alarm\*

Connect an ECG and an AP signal to the unit and begin pumping. While pumping, remove the AP signal.

#### **Class 3**

Battery Inoperative      Done previously during step 10 of this procedure.

On Battery

Done previously during step 10 of this procedure.

Deflation > 100%

Move the deflation marker past the 100% point.

#### **Class 2**

ECG Lead Fault      Remove an ECG lead from the simulator.

ECG Trigger Loss      While pumping with an ECG trigger, remove the ECG signal.

AP Trigger Loss

While pumping with an AP trigger, remove the AP signal.

### **Class 1**

- |                   |  |
|-------------------|--|
| Purge Failure     | Press Pump On with no active trigger.  |
| Large Helium Leak | With the unit pumping, disconnect the balloon tubing.  |
| High Pressure     | Kink the balloon tubing 3 feet from the IABP,<br>start pumping.  |
| System Error      | Remove jumper JP3 from the lower left corner of the CPU pcb.<br>Note: System Error alarms also produce a piezo beeping tone. |

### **Battery Test**

Operate the system on battery power. It should operate for a minimum of 90 minutes. After 90 minutes of battery operation has been achieved, reconnect AC power to the unit and allow the battery to recharge.

Note that due to the design of the AutoCAT™2 Series IABP, the current drawn by the unit is nearly constant regardless of the operating conditions. Therefore, the various operating conditions encountered during the completion of this procedure should not have a significant effect on the battery run time of the unit.

### **AutoPilot™ Checkout**

Place the unit in AutoPilot™ Mode. Connect a patient simulator with ECG, AP, and Assist to the unit. Also connect a balloon simulator to the unit. Begin pumping. Observe the operating parameters (ECG lead, trigger mode, inflation / deflation timing) selected by the unit. In most cases the trigger mode will be ECG Pattern in lead II, and the timing of the AP waveform should look correct (refer to diagram of a properly timed AP waveform found in Chapter 4 of this manual).

Remove an active ECG lead (i.e. RA lead) from the simulator so that the ECG waveform is lost. The unit should automatically switch to a different ECG lead configuration and resume pumping.

Remove the ECG cable completely. The unit should automatically switch to AP trigger mode and continue pumping.

Fully reconnect the ECG signal to the unit. Allow sufficient time for the unit to return to an ECG trigger mode as displayed in the upper right corner of the LCD. Switch to the unit to Operator Mode. The timing bar will appear on the bottom of the LCD. Move the inflation to point to 25% and the deflation point to 90%. With the unit pumping, observe the AP waveform. It should appear to be poorly timed. Switch the unit to AutoPilot™ and observe that the shape of the AP waveform changes to that of a properly timed AP waveform (refer to diagram of a properly timed AP waveform found in Chapter 4 of this manual).

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

#### PM CHECKLIST - AUTOCAT™2 SERIES IABP

Unit Serial # \_\_\_\_\_ System Software Rev \_\_\_\_\_ FCN Level \_\_\_\_\_ RTM \_\_\_\_\_

##### Initial Inspection

- Clean unit exterior and interior
- Locate accessories/note missing items
- Update FCNs/Software as appropriate

##### ECG, AP Signal and Trigger

- Low Level ECG (all leads)
- High Level ECG (in/out)
- Low Level AP
- High Level AP (in/out)
- BP/Assist (Outputs)
- Pattern
- Peak
- AFIB
- VPACE
- APACE
- AP
- Internal

##### Mechanical Integrity

- Loose Hardware or Handles
- Power Cord/Umbilical Cable
- Casters/Brakes
- Front and Side Panels
- Loose PCBs or Assemblies
- Water Bottle (missing or full)
- Cut, Kinked, Misrouted Cables/Tubing
- Balloon Connector
- Rotation Latch

##### Check and Adjust as Required

- Raise/Lower Mechanism
- Helium Regulator 6PSI + 2PSI

##### Additional Checks

- Confirm Modem Operation
- Flash Card (read/write)
- Displacement Volume (30cc, 40cc, 50cc)
- Augmentation Step (-40 mmHg)
- Drain Task/Auto Fill Function

##### Check and Verify

- Check Operation in AC and DC
- +5V + 0.25V (C81 on CPU)
- +12V ( 11.8V / 13.2V)(C82 on CPU)
- 12V (- 11.8V / - 13.8V)(Blue wire on pin 6 of Front End power cable)
- +54V (50V to 57V – Big Blue Cap)
- #1 Charger 13.4V to 14.2V
- #2 Charger 13.4V to 14.2V(if applicable)
- Stepper Motor Current (approx 4.25A)
- Recorder Operation
- BP Transducer
- Static RAM Memory
- Cold Trap Thermal Element
- 3 Fans - clean/working (PCS/PS/Main)
- Audio, Piezo and Speaker
- Control/Display (keys & visual)
- Calendar / Clock
- FOS (AutoCAT™2 Wave units only)
- Power Alarm BD

##### Simulate Select Alarm Conditions

###### Class 4

- No ECG Available
- No AP Available

###### Class 3

- System Running on Battery
- Battery Inoperative
- Deflation > 100%

###### Class 2

- ECG Lead Fault
- ECG Trigger Loss
- AP Trigger Loss

###### Class 1

- Purge Failure
- Large Helium Leak
- High Pressure
- System Error

##### Battery Test

- Battery Load Test

##### AutoPilot™ Checkout

- Verify AutoPilot™ Operation

Notes / Comments:

Signature

Date

### **Electrical Safety Test Procedure**

Arrow International recommends that you perform the electrical safety test described on the following pages at annual intervals to verify that the AutoCAT™2 meets the standards outlined in the procedure.

Arrow International recommends that you use special electrical safety test equipment to perform this test. The procedure contained on these pages was written with regards to the specific equipment mentioned below. Other comparable equipment may be substituted provided it achieves comparable results.

Because certain parts of these tests involve high voltage, appropriate safety precautions should be observed by the operator while conducting this test.

#### **REFERENCE**

UL Standard UL 2601

International Standard IEC 601-1

#### **EQUIPMENT**

Bio-Tek Instruments 505 Safety Analyzer

Cable with single banana plug on one end and a clip on another end

Associated Research Ground Bond Tester Model 5030DT with two cables

Power cord with known resistance value

Hipotronics high pot tester 100 series

High Pot Test Fixture

120V to 240V Step-up transformer

Auto-transformer 0V/140V

#### **PROCEDURE**

NOTE: The following abbreviations are used through the procedure:

UUT unit under test (IABP)

CW clockwise

CCW counter clockwise

AP Arterial Pressure

ECG Electrocardiogram

TP Test Point

#### **Enclosure Leakage Test Using Bio-Tek 505 Safety Analyzer**

NOTE: Remove all inputs and outputs from the UUT before performing safety tests.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

---

#### ***Line Voltage Set-up***

- Connect auto-transformer to 110V outlet. Turn voltage knob all the way CCW. Set switch to OFF position. Connect step-up transformer into auto-transformer. Connect safety analyzer into step-up transformer.
- Turn analyzer ON.
- Turn auto-transformer switch to ON position and adjust auto-transformer to approximately 115V.
  - Analyzer turns ON, performs line check and displays.
  - Verify that dual lead LED is OFF.
  - Press VOLTAGE key.
  - Verify that V LED is ON.
  - Analyzer measures and displays for 2 seconds each of the following voltages:
    - HOT-NEUTRAL
    - HOT-GROUND
    - NEUTRAL-GROUND
  - Using the analyzer display adjust auto-transformer knob to get 264V +/- 2V reading. Enter all 3 readings into the table:

**NOTE:** Voltage must be steady to perform this part of the test

	H-n (Hot-neutral) (264V +/- 2V)	H-Gn (Hot-Ground) (+/- 2V of H-n)	n-Gn (neutral-Ground) (1V max)
Analyzer reading			

#### ***Chassis To Ground Leakage Test***

- Press CHASSIS LEAK key.
- Verify that micro A LED is ON.
- Turn UUT power switch OFF.
- Plug UUT power cord into Analyzer TEST RECEPTACLE.
- Connect single-ended banana plug to RED binding post.
- Connect clip to EARTH GROUND on the chassis.

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

*Set the following test condition:*

- UUT power switch OFF
- reverse polarity LED to OFF
- open ground LED to OFF
- open neutral LED to OFF

*Read the display and record the result:*

UUT power	Test Condition	Leakage Reading
OFF	OFF reverse polarity OFF open ground OFF open neutral	(100 microA max)

*Set the following test condition:*

- UUT power switch OFF
- reverse polarity LED to ON
- open ground LED to ON
- open neutral LED to OFF

*Read the display and record the result:*

UUT power	Test Condition	Leakage Reading
OFF	ON reverse polarity ON open ground OFF open neutral	(500 microA max)

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

---

*Set the following test condition:*

- UUT power switch OFF
- reverse polarity LED to OFF
- open ground LED to ON
- open neutral LED to ON

Read the display and record the result:

UUT power	Test Condition	Leakage Reading
OFF	OFF reverse polarity ON open ground ON open neutral	(500 microA max)

NOTE: The following test must be performed as written.

Possible damage to the equipment may result if not followed correctly.

*Set the following test condition*

- UUT power switch OFF
- reverse polarity LED to ON
- open ground LED to ON
- open neutral LED to OFF
- UUT power switch ON

Read the display and record the result:

UUT power	Test Condition	Leakage Reading
ON	ON reverse polarity ON open ground OFF open neutral	(500 microA max)

NOTE: The following test must be performed as written.

Possible damage to the equipment may result if not followed correctly.

*Set the following test condition:*

- UUT power switch OFF
- reverse polarity LED to OFF
- open ground LED to OFF
- open neutral LED to OFF

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

- UUT power switch ON

Read the display and record the result:

UUT power	Test Condition	Leakage Reading
ON	OFF reverse polarity OFF open ground OFF open neutral	(100 microA max)

Set the following test condition:

- UUT power switch ON
- reverse polarity LED to OFF
- open ground LED to ON
- open neutral LED to OFF
- Press DC only key

Read the display and record the result:

UUT power	Test Condition (DC Only)	Leakage Reading
ON	OFF reverse polarity ON open ground OFF open neutral	(500 microA max)

- Set open ground LED to OFF.
- Turn UUT power switch OFF.
- Disconnect clip from UUT.

#### ***ECG Leads Test Using Bio-Tek 505 Safety Analyzer***

#### ***ECG Leads Leakage Test***

- Turn UUT power switch OFF.
- Connect 5 lead ECG cable to UUT ECG signal low level input connector and then connect each lead to the appropriate binding post on Analyzer.
- Press ECG lead key.
- Verify that microA LED is ON.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

---

*Set the following test condition:*

- UUT power switch OFF
- reverse polarity LED to OFF
- open ground LED to OFF
- open neutral LED to OFF

Using SELECTION keys read the display for different leads combination and record the highest reading on the display into the table:

UUT power	Test Condition	Leakage Reading Highest
OFF	OFF reverse polarity OFF open ground OFF open neutral	(10 microA max)

*Set the following test condition:*

- UUT power switch OFF
- reverse polarity LED to ON
- open ground LED to ON
- open neutral LED to OFF

Using SELECTION keys read the display for different leads combination and record the highest reading on the display into the table:

UUT power	Test Condition	Leakage Reading Highest
OFF	ON reverse polarity ON open ground OFF open neutral	(50 microA max)

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

---

*Set the following test condition:*

- UUT power switch OFF
- reverse polarity LED to OFF
- open ground LED to ON
- open neutral LED to ON

Using SELECTION keys, read the display for different leads combination and record the highest reading on the display into the table:

UUT power	Test Condition	Leakage Reading Highest
OFF	OFF reverse polarity ON open ground ON open neutral	(50 microA max)

NOTE: The following test must be performed as written.

Possible damage to the equipment may result if not followed correctly.

*Set the following test condition*

- UUT power switch OFF
- reverse polarity LED to ON
- open ground LED to ON
- open neutral LED to OFF
- UUT power switch ON

Using SELECTION keys read the display for different leads combination and record the highest reading on the display into the table:

UUT power	Test Condition	Leakage Reading
ON	ON reverse polarity ON open ground OFF open neutral	(50 microA max)

NOTE: The following test must be performed as written.

Possible damage to the equipment may result if not followed correctly.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

---

*Set the following test condition:*

- UUT power switch OFF
- reverse polarity LED to OFF
- open ground LED to OFF
- open neutral LED to OFF
- UUT power switch ON

Using SELECTION keys read the display for different leads combination and record the highest reading on the display into the table:

UUT power	Test Condition	Leakage Reading Highest
ON	OFF reverse polarity OFF open ground OFF open neutral	(10 microA max)

*Set the following test condition:*

- UUT power switch ON
- reverse polarity LED to OFF
- open ground LED to ON
- open neutral LED to OFF
- Press DC only key

Using SELECTION keys read the display for different leads combination and record the highest reading on the display into the table:

UUT power	Test Condition (DC Only)	Leakage Reading Highest
ON	OFF reverse polarity ON open ground OFF open neutral	(50 microA max)

- Set open ground LED to OFF.

### ***ECG Leads Isolation Test***

**CAUTION:** During isolation test, line voltage is present at ECG terminals.  
Current flow is limited to 1 mA.

- Set UUT power switch to ON.
- Press ECG lead key.
- Verify that microA LED is ON.
- Set cursor to LEAD ALL-GND.
- Press and hold isolation key.
- Analyzer beeps and displays leakage current for this lead.
- Release isolation key.

Using selection and isolation keys measure leakage current for V-GND, LL-GND, LA-GND, RL-GND and RA-GND leads. Enter the highest reading into the table:

UUT power	Test Condition	Leakage Reading Highest
ON	Isolation Key is pressed	(50 microA max)

- Unplug UUT AC cord from the Analyzer.
- Turn auto-transformer knob all the way CCW. Set switch to OFF position.

### ***UUT Power Ground Line Resistance Test Using Associated Research Ground Bond Tester Model 5030DT***

#### ***Ground Bond Tester Set-up***

- Turn Tester power switch OFF.
- Plug Tester power cord into 120V AC outlet.
- Turn Tester power switch ON.
- Using CURRENT key set test current to 25A.
- Using VOLTAGE key set test voltage to 6V.
- Using HI-LIMIT key set high limit resistance trip to 90 milliohms.
- Using LO-LIMIT key set low limit resistance trip to 0 milliohm.
- Using DWELL key set the time to 10 sec.
- Using 50/60 Hz key set frequency to 60Hz.

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

---

#### ***UUT Power Ground Line Resistance Test***

NOTE: Use designated power cord of known resistance. This resistance is automatically subtracted from the value measured.

- Connect designated power cord into AC Test Inlet and into UUT power entry module.
- Turn UUT power OFF.
- Connect Tester Black probe to power cord GND TP. Connect Tester Red probe to UUT EARTH GROUND on the chassis.
- Verify that Tester displays the following setting:

Set M1      10 sec

25 A      90 mOhm

- Press TEST switch.
- Wait 10 sec.
- Verify that Tester beeps once and displays PASS symbol.
- Read the display (right lower corner) and record the resistance

NOTE: If the failure occurs, Tester alarms continuously and displays FAIL symbol. Press RESET switch and Tester displays the failure information. Press RESET switch again and Tester is ready for the next test.

NOTE: Test can be aborted by pressing RESET switch at anytime.

- Disconnect clips from UUT.

Parameter	Nominal Value	Actual Reading
Power Ground Line Resistance	< 90 milliohms	(milliohms)

#### ***Dielectric Withstand Tests Using Hipotronics High Pot Tester 100 series.***

##### ***High -Pot Tester Set -up***

- Turn Tester power switch OFF.
- Plug Tester power cord into 120V AC outlet.
- Turn Tester power switch OFF.
- Set VOLTAGE RANGE knob to MED.SET
- Set RAISE VOLTAGE knob to ZERO START
- Set OUTPUT CURRENT knob to DCx100 microamps.

## 6. Maintenance and Service

### 6.1: Routine Maintenance Procedures

---

- Turn OVERLOAD SENS. knob all the way clockwise.  
Dielectric Strength Line Hot to Ground.
- Connect UUT power cord into AC Test Inlet. Turn the UUT OFF.
- Connect Tester Black probe to power cord GND TP.
- Connect Tester Red probe to power cord HOT TP.
- Turn Tester ON.
- Press HIGH VOLTAGE ON switch.
- Using RAISE VOLTAGE knob gradually raise voltage over a period of 10 sec to 2120 VDC
- Hold voltage for 60 sec.
- Verify that OVERLOAD FAILURE light is OFF.
- Set RAISE VOLTAGE knob to ZERO START
- Press HIGH VOLTAGE OFF switch.

NOTE: If the failure occurs, Tester alarms continuously and OVERLOAD FAILURE light is ON. Press RESET switch and turn RAISE VOLTAGE knob to ZERO START. Tester is ready for the next test.

NOTE: Test can be aborted by pressing HIGH VOLTAGE OFF switch at anytime.

Parameter	P-pass	F-fail
Hi Pot test		
Hot to Ground		

- Dielectric Strength ECG Input and AP Input to Line Hot
- Connect ECG and AP cables into ECG and AP inputs of the UUT.
- Connect UUT power cord into AC Test Inlet.
- Turn the UUT OFF.
- Connect Tester Black probe to ECG TP.
- Connect Tester Red probe to power cord HOT TP.
- Press HIGH VOLTAGE ON switch.
- Using RAISE VOLTAGE knob gradually raise voltage over a period of 10 sec to 5640 VDC
- Hold voltage for 60 sec.
- Verify that OVERLOAD FAILURE light is OFF.
- Set RAISE VOLTAGE knob to ZERO START

## **6. Maintenance and Service**

### **6.1: Routine Maintenance Procedures**

---

- Press HIGH VOLTAGE OFF switch.

NOTE: If the failure occurs, Tester alarms continuously and OVERLOAD FAILURE light is ON. Press RESET switch and turn RAISE VOLTAGE knob to ZERO START.

Tester is ready for the next test.

NOTE: Test can be aborted by pressing HIGH VOLTAGE OFF switch at anytime.

- Connect Tester Black probe to AP TP.
- Press HIGH VOLTAGE ON switch.
- Using RAISE VOLTAGE knob gradually raise voltage over a period of 10 sec to 5640 VDC
- Hold voltage for 60 sec.
- Verify that OVERLOAD FAILURE light is OFF.
- Set RAISE VOLTAGE knob to ZERO START
- Press HIGH VOLTAGE OFF switch.

NOTE: If the failure occurs, Tester alarms continuously and OVERLOAD FAILURE light is ON. Press RESET switch and turn RAISE VOLTAGE knob to ZERO START.

Tester is ready for the next test.

NOTE: Test can be aborted by pressing HIGH VOLTAGE OFF switch at anytime.

Parameter	P-pass	F-fail
Hi Pot test Hot to ECG		
Hi Pot test Hot to AP		

- Disconnect designated power cord from UUT.

## **General**

Prior to removing any portions, or servicing the AutoCAT™2, power sources should be removed. AC can be removed from the AutoCAT™2 by removing the AC fuses at the power entry module or by removing the AC power cord. DC (battery) power can be removed by switching OFF the DC circuit breaker or by disconnecting the wires to the battery.

Both AC and DC power must be removed in order to safely service the AutoCAT™2.

When working with or handling electronic components and circuit boards, precautions to protect these devices from electro-static discharge (ESD) must be observed. These include, at a minimum, the wearing of ESD protective devices (i.e. ESD wrist straps) by any individuals handling the electronic components or boards. Also packing, storing, moving and shipping the electronic components or boards in ESD protective containers/bags.

## **Right Side Cover**

On the front connector panel, there are three screws on each side. Remove the middle screw on the right side. On the lower rear portion of the side cover (where it meets the other side cover) there are two screws and a bracket securing the two covers together. At least one screw must be removed in order to remove either cover. Pull down on the two captive retaining clips under the bottom edge of the right side cover. Pull the bottom of the side cover away from the AutoCAT™2.

To reinstall, follow these steps in reverse order.

## **Left Side Cover**

On the front connector panel, there are three screws on each side. Remove the middle screw on the left side. On the lower rear portion of the side cover (where it meets the other side cover) there are two screws and a bracket securing the two covers together. At least one screw must be removed in order to remove either cover. Pull down on the two captive retaining clips under the bottom edge of the left side cover. Unlatch the helium tank lock and tilt the tank outward. Remove the IV pole mounting block by removing the two screws which secure it to the chassis.

Gently pull the bottom of the side cover away from the AutoCAT™2. Be aware that in addition to the hardware which secures the left side cover, there are several cables and tubing attached to the left side cover. The length of these cables and tubing is such that it is possible to move the side cover far enough away from the chassis to allow access to these cables and tubing. It will be necessary to reach behind the side cover and disconnect the cables and tubing in order to fully remove the cover.

To reinstall, follow these steps in reverse order.

## **6. Maintenance and Service**

### **6.2: Removal and Replacement Instructions**

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#### **Front Connector Panel**

Remove the three screws on each side of the front connector panel. Remove the two screws under the bottom center of the panel. Remove the two screws on the top edge of the panel.

At this point the front panel is detached from the chassis however there are several cables and tubing which run from the front panel to the chassis. If the front panel is to be completely removed from the AutoCAT™2, it will be necessary to disconnect all cables and tubing which run between the front panel and the chassis.

In some cases, it may not be necessary to completely remove the front panel from the AutoCAT™2 (i.e. to remove the pump assembly or the pneumatic manifold assembly). In such cases it is only necessary to remove the screws mentioned earlier and disconnect some of the cables and tubing. The front panel can then be rotated 90 degrees and supported by (or hung from) the Top Handle with a length of rope or other means. Once supported and out of the way, items such as the pump assembly can then be removed.

To reinstall, follow these steps in reverse order.

#### **Battery**

Remove the right side cover. Follow the Battery Replacement Procedure in Section 6.1 of this manual.

#### **Power Supply**

Remove the right and left side covers. Open the hinged door on which the CPU board is mounted by unscrewing the four captive screws and disconnecting the cables which prevent the door from fully opening.

**Note:** Two of these cables, the ones that run from the low level inputs to the Front End board, pass under the shield. If there are no in-line connectors, it will be necessary to remove the shield from the door, in order to disconnect these two cables. If so, reference the instructions for Front End Board removal and replacement for details on how to do this.

Disconnect the output cables from the front side of the power supply. Disconnect the negative lead to the circuit breaker and the positive lead to the battery. If the optional second battery is installed, there are two positive leads that must be disconnected. Remove the three screws for the rear side of the power supply that secure it to the frame. Remove the power supply from the chassis, disconnecting the AC input line in the process.

To reinstall, follow these steps in reverse order.

### **Pump Assembly**

Fully remove the front panel (or partially remove the front panel and suspend it from the top handle). Remove the left side cover and the right side cover. If a helium tank is installed, remove it. Disconnect the cables from the pump assembly. Disconnect the helium source line to the pump assembly. Disconnect the coldtrap drain tubing from the pump assembly. Disconnect the helium line out from the pump assembly. Remove the augmentation chamber tubing from the coldtrap. Remove the four screws on the underside of the AutoCAT™2 which hold the pump assembly to its mounts. Remove the pump assembly out through the front lower portion of the front panel opening.

To reinstall, follow these steps in reverse order. To reattach the helium out line of the pump assembly, simply push the helium tubing down into the hole until it reaches the bottom.

### **Pneumatic Manifold Assembly**

Fully remove the front panel (or partially remove the front panel and suspend it from the top handle). If a helium tank is installed, remove it. Disconnect the cable from the pneumatic manifold assembly. Disconnect the helium source line to the pump assembly. Disconnect the coldtrap drain tubing from the pump assembly. Disconnect the helium line out from the pump assembly. Remove the augmentation chamber tubing from the coldtrap.

Remove the two screws in the center of the pneumatic manifold assembly which secure it to the pump assembly. Pull the pneumatic manifold assembly off of the pump assembly.

**Note:** There is an o-ring seal between the pneumatic manifold assembly and the pump assembly.

To reinstall, follow these steps in reverse order.

## 6. Maintenance and Service

### 6.2: Removal and Replacement Instructions

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#### CPU PCB

Remove the right side cover. Disconnect the cables to the CPU board. Remove the screws which are securing the CPU board to the chassis.

To reinstall, follow these steps in reverse order.

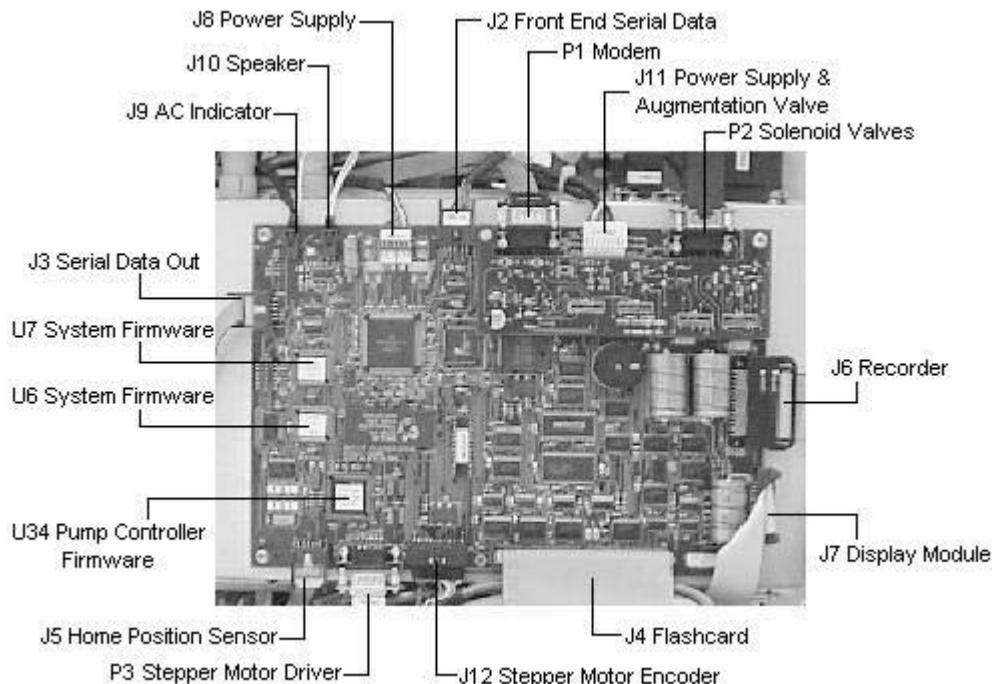
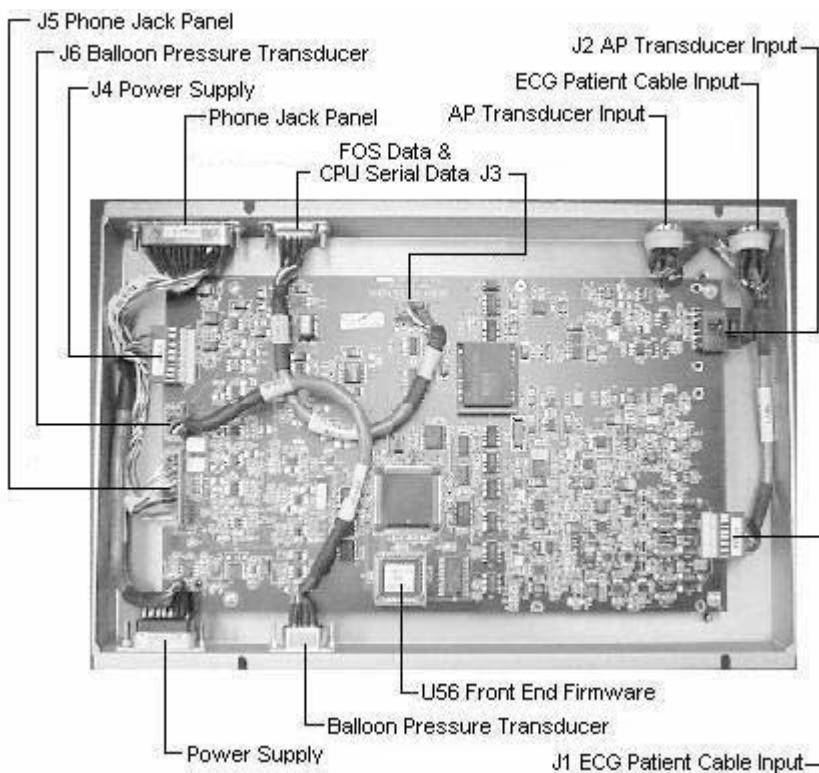


Figure 6.6: CPU PCB Connections

## Front End PCB

Remove the right side cover. Disconnect the cables from the CPU board. Disconnect the cables from the shield. Remove the four screws that are securing the shield to the hinged door. Remove the shield from the door. Remove the screws that are securing the Front End board to the shield.

To reinstall, follow these steps in reverse order.



*Figure 6.7: Front End PCB Connections*

## **6. Maintenance and Service**

### **6.2: Removal and Replacement Instructions**

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#### **FOS PCB (AutoCAT™2 WAVE only)**

Remove the both side covers of the AutoCat 2 IABP. The FOS pcb is on the left side of the unit, mounted to the center frame panel with 4 screws.

Disconnect the three cables from the pcb (J1, J3, and Power).

Remove the blue vent shroud from the fiber optic block by pulling it straight out off the block.

Disconnect the fiber optics cable from the front panel (on the top right side of the unit) by grasping the white colored part of the connector at the lowest possible point and pulling upward. Carefully feed the fiber optic cable out the left side of the unit. Exercise caution when handling the fiber optic cable to avoid physical damage. Also, do not touch the center tip of the fiber optic cable as any deposits could distort the fiber optic signal.

Remove the four screws that hold the pcb to the frame. On the back side of the pcb there are 4 spacers that keep the pcb slightly off of the frame to allow space for the fiber optics cable behind the pcb. Exercise caution when removing the screws that the spacers are not lost. There is also an insulating panel between the pcb and the frame. Remove the pcb with the fiber optic cable from the unit.

To install, reverse the above steps. When connecting the fiber optics cable to the front panel, note that the connector is polarized and will only install one way. Once aligned, it should slide into place with easily. Push the connector in until a click is heard, indicating it is locked into position.

### **Stepper Motor Controller**

Remove the right side cover. Open the hinged door on which the CPU board is mounted by unscrewing the four captive screws and disconnecting the cables which prevent the door from fully opening.

Disconnect the two cables on the stepper motor controller. Remove the four screws and washers that are securing the stepper motor controller to the chassis.

To reinstall, follow these steps in reverse order.

### **Helium Regulator Assembly**

Remove the left side cover. If a helium tank is installed, remove it. Remove the two pivot screws that secure the regulator assembly to the chassis. Observe the order of the washers that are used at these locations. Care should be taken to follow this same order in reassembly. Disconnect the helium out line from the regulator and the cable from the transducer.

To reinstall, follow these steps in reverse order.

### **LCD / Keyboard Controller**

The LCD and keyboard controller can be accessed by removing the screws on the backside of the display module. With these screws removed, the front and rear covers of the display module can be separated. All of the internal components are mounted to the front cover.

The LCD and its power supply are mounted to a metal bracket. This bracket is secured to the inside surface of the front cover. The keyboard controller circuitry is built onto the keyboard overlay as one assembly. It is secured to the outside surface of the front cover.

To remove the LCD or the power supply, first separate the front and back covers of the display module, remove the screws holding the metal mounting bracket to the front cover, separating the interconnecting ribbon cables in the process, then remove the mounting bracket / LCD assembly. The LCD or power supply can then be removed from the bracket. To reinstall, follow these steps in reverse order.

To remove the keyboard controller / keyboard overlay, first remove the LCD as outlined above, then remove the nuts that secure the keyboard to the front cover. There may also be an area of adhesive around the perimeter of the keyboard. If so, it will be necessary to overcome the adhesive in order to remove the keyboard. To reinstall the keyboard, follow these steps in reverse order. When laying the new keyboard onto the front panel, check to be certain that the keyboard is properly positioned on the front cover then apply pressure around the perimeter to set the adhesive. Extra caution should also be taken to avoid touching the inside surface of the display window on the keyboard. Doing so may leave undesired dirt on marks visible after assembly when viewing the LCD.

## **6. Maintenance and Service**

### **6.2: Removal and Replacement Instructions**

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#### **Recorder**

To remove the recorder, open the paper door by pressing on the grooved finger pad. Remove any paper that may be in the recorder. Loosen the two screws at the back of the paper storage compartment and pull the recorder out from the front panel, disconnecting the ribbon cable in the process. To reinstall, reverse these steps.

#### **Raise and Lower Mechanism**

The raise and lower mechanism can be removed from the AutoCAT™2 by lifting the entire assembly out of the AutoCAT™2.

**Caution:** Raise and lower mechanisms contain a roll spring that is under constant tension. The function of this roll spring is to counter-balance the weight of the display module when it is mounted on the AutoCAT™2, thus requiring less effort to raise or lower the display. When removing, installing or servicing the raise and lower mechanism, extra caution should be observed to prevent inadvertent unloading of this spring. If it is necessary to unload this spring for any reason, the raise and lower mechanism should be held in a secure manner (such as in a clamp or vise), to allow the technician to unload or load the spring in a controlled manner.

To remove the new model raise and lower mechanism, remove both side covers then remove the two screws that hold the rotation bearing to the base of the frame. The entire mechanism can then be lifted up and out of the AutoCAT™2. The display mounting base, the handle assembly and / or the column can be removed from the raise and lower mechanism at any time. This can be done either after the raise and lower mechanism has been removed from the AutoCAT™2 or while it is still installed in the AutoCAT™2.

To reinstall, reverse the above steps.

#### **Alarm Bd, Modem Bd, and Speaker**

The above titled components are located just inside the front right frame support upright. They are help in mounted using standard hardware. Remove and replace using appropriate tools and hardware.

#### **Augmentation Chamber and Valve**

The above titled components are located just inside the front left frame support upright. They are help in mounted using standard hardware. Remove and replace using appropriate tools and hardware.

### **Service Information**

If the AutoCAT™2 requires preventive or corrective maintenance service, or if you need assistance with an operational problem, call your Arrow International Field Service Representative. You can receive clinical/technical assistance 24 hours a day by calling:

**1-800-447-IABP (U.S.A. & Canada)**

**or**

**1-617-389-8628**

**(outside the U.S.A. & Canada)**

### **Ordering Parts, Supplies, Options and Accessories**

You can order parts, supplies, options and accessories by calling or writing Arrow International:

Arrow International, Inc.  
Customer Service Department  
2400 Bernville Road  
Reading, PA 19605

1-800-523-8446  
Orders Only FAX: 1-800-343-2935

1-610-478-3196  
Fax: 1-610-478-3195  
(Outside the U.S.A. & Canada)

Call or write to verify prices before ordering. The order should specify item name, part number, price and quantity.

## **6. Maintenance and Service**

### **6.3: Service and Ordering Information**

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<b>ORDERING INFORMATION</b>		
<b>Name</b>	<b>Catalog Number</b>	<b>Description</b>
<b>ECG CABLES (5-LEAD)</b>		
ECG Cable Assembly	IAA-09837	Complete 5 lead ECG cable consisting of one IAA-09838 and one IAA-09839 (15 ft/4.5M) AHA(US) Clip colors
ECG Cable Assembly	IAA-09837E	Complete 3 lead ECG cable consisting of one IAA-09838 and one IAA-09839E (15 ft/4.5M) IEC (European Clip colors)
ECG Trunk cable	IAA-09838	Five lead main trunk cable (12 ft/3.7M)
ECG Cable Clip Ends	IAA-09839	Five lead patient cable, clip ends (39in/1M) AHA (US) Colors
ECG Cable Clip Ends	IAA-09839E	Five lead patient cable, clip ends (39in/1M) IEC (European)Colors
ECG Backpad cable	IAA-04305	For use with ConMed/NDM five lead backpad electrodes

\* BAM approved Post Medical Valve. Meets ECC requirements for Belgium, France, Germany, Netherlands, and U.K.

**6. Maintenance and Service**  
**6.3: Service and Ordering Information**

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<b>ORDERING INFORMATION</b>		
<b>Name</b>	<b>Catalog Number</b>	<b>Description</b>
<b>SLAVE CABLES</b>		
Phone to Phone	IAA-00003	Cable for connecting ECG or AP monitor signal to AutoCAT™2 Series (25 Ft/ 8 M)
Phone to 3.5 mm Miniphone	IAA-03720	For connecting ECG or AP from Hewlett Packard monitors to AutoCAT™2 Series (25ft/8 M)
Phone to 4.4 mm Bantam	IAA-03712	For connecting ECG or AP from Spacelabs monitors to AutoCAT™2 Series (25ft/8 M)
Siemens 9000 monitor connection to AutoCAT™2 Series	IAA-00502	For connecting ECG or AP from Siemens monitor 9000 series to AutoCAT™2 Series (25ft/8 M)
Siemens 1280 monitor connection to AutoCAT™2 Series	IAA-00501	For connecting ECG and AP from Siemens monitor 1280 series to AutoCAT™2 Series (25ft/8 M)
GE/Marquette	IAA-H-8047	GE/Marquette 7010 Cable Assembly connects ECG and AP signal
GE/Marquette	IAA-H-8051	GE/Marquette Lemo Connector Assembly connects ECG and AP signal
<b>RECORDER PAPER</b>		
Recorder Paper	IAA-09004	10 roll box of 50mm blank thermal paper for AutoCAT™2 Series strip chart recorder. (275 ft per roll)
<b>HELIUM</b>		
Helium tanks	IAH-09045	Case of 4 disposable canisters 33 liters @ 500 psi
	IAH-09047	Refillable with standard yoke fitting and European (BAM) approval, 100 liters @ 2900 psi
	IAH-09048	Refillable with standard yoke fitting and US approval, 106 liters @ 2000 psi
Helium tank adapter	IAH-09145	Adapter which allows 500 psi disposable tank to be used in standard yoke assembly
Helium washers	2500-9085-002	Fits between tank and/or tank adapter to seal tank

\* Specify manual language (-), French (F), German (D), Italian (I), Japanese (J), or Spanish (E).

## 6. Maintenance and Service

### 6.3: Service and Ordering Information

ORDERING INFORMATION		
Name	Catalog Number	Description
<b>UMBILICAL CORD</b>		
Umbilical Cord	IAA-03701	Monitor to control unit cable 12 ft. Standard Length
Umbilical Cord	IAA-09115	Monitor to control unit cable 15 ft. Extended Length
<b>MODEL 2001 &amp; 2701 SIMULATOR INTERACTIVE</b>		
Model 2701 Patient Simulator	IAT-00010 (115V) or IAT-00011 (220V)	Interactive hemodynamic ECG/AP/Axillary pressure simulator; battery operated, computer based training system, produces synchronized ECG, AP and auxiliary pressure waveforms at different pulse rates, including dysrhythmias, when used with the AutoCAT™2 Series; includes battery charger, 3 phone-RCA cables
Simulator charger	IAT-00020	115V AC Charger for Arrow International Model 2701 IAB simulator
Simulator charger	IAT-00021	220V AC Charger for Arrow International Model 2701 IAB simulator
Load simulator	IAT-00025	Load simulator to simulate IAB attached to AutoCAT™2 Series IABP system.
Volume Calibrator	IAT-00030	Hydraulics simulator used to measure volume displacement of IABP
Model 2001 Universal Simulator	IAT-00201	Arrow Model 2001 Intra-Aortic Pump Simulator (120V) Balloon Pump Console Interactive Hemodynamic ECG/AP/Auxiliary Pressure Training Simulator
	IAT-00221	Battery Operated, Computer Based Training System produces synchronized ECG, arterial and auxiliary pressure waveforms at variable pulse rates including dysrhythmia when used with K-2000, M-7000 and KAAT, ACAT® and AutoCAT™ Series IABP Control Consoles. Signal input selections such as No ECG with AP or No ECC lead II selectable by user. Includes battery charger, three phone-to-phone cables, one 9 Pin DB to 9 Pin DB cable and one Operator's manual.
Simulator Cables	IAT-09843	Arrow Model 2001 Intra-Aortic Pump Simulator (220V) Balloon Pump Console Interactive Hemodynamic ECG/AP/Auxiliary Pressure Training Simulator (Components as listed above. Continental European Plug.)
	IAT-09844	Low Level Arterial Pressure Cable with 4.4 mm plug to 6 Pin connector (For use with Datascope IABP systems)
	IAT-09845	Low Level Arterial Pressure Cable with 4.4 mm plug to Orange Nicholay Connector (For use with ACAT®/KAAT Series and K-2000 IABP systems)
	IAT-09846	Low Level Arterial Pressure Cable with 4.4 mm plug to 6 Pin AAMI connector (For use with Transact IABP systems)
	IAT-09847	Low Level Arterial Pressure Cable with 4.4 mm plug to 6 Pin AAMI connector (For use with AutoCAT™ IABP systems)
		Assist out to 4.4 mm plug (For use with Datascope IABP systems)

**6. Maintenance and Service**  
**6.3: Service and Ordering Information**

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<b>ORDERING INFORMATION</b>		
<b>Name</b>	<b>Catalog Number</b>	<b>Description</b>
<b>MODEL 2001 &amp; 2701 SIMULATOR INTERACTIVE (continued)</b>		
	IAT-09848	9 Pin DB to 9 Pin DB (For use with TransAct® or AutoCAT™ IABP systems)
	IAT-09849	Phone-to-Phone cable (10 Ft/3M)
<b>MANUALS</b>		
Operators Manual	IAM-9005(D, E, F, I, J, P, PL)	AutoCAT™2 Series Operator's Manual Available in : German Spanish French Italian Japanese Polish * Portuguese*
Service Manual	IAM-9006	AutoCAT™2 Series Service Manual English Only  * Check for Availability
<b>MOUNTING HARDWARE &amp; BRACKETS</b>		
IV Pole Mounting to any Bracket	IAA-00170	Allow mounting of the AutoCAT™2 Series Control module IV pole from 1/2 inch diameter to 4 inches.
Aircraft Lockdown Brownline Bracket	IAA-00100	Allows mounting of the AutoCAT™2 Series into the tracking system of an aircraft. Adjustable dimensions.
Dual Hanger IV Pole	IAA-00175	For holding AP transducer and pressure bag. Pole extends from 28" to 52" (71 to 132 cm)

## **6. Maintenance and Service**

### **6.3: Service and Ordering Information**

<b>ORDERING INFORMATION</b>		
<b>Name</b>	<b>Catalog Number</b>	<b>Description</b>
<b>POWER CORDS</b>		
Power cords	IAA-09650	Detachable power cord with North American plug configuration. (12 ft/3.5 M)
	IAA-09660	Detachable power cord with North American plug configuration. (15 ft/4.5 M)
	IAA-09670	Detachable power cord with continental European plug configuration. (12 ft/3.5 M)
	IAA-09680	Detachable power cord with continental European plug configuration. (15 ft/4.5 M)
	IAA-09695	Detachable power cord with Australian plug configuration. (15 ft/4.5 M)
	IAA-09690	Detachable power cord with UK plug configuration. (15 ft/4.5 M)
<b>BATTERY AND FUSES</b>		
Battery	4000-9022-001	12 V Battery for DC operation
Battery Upgrade Kit	IAU-00100	Extends battery life of AutoCAT™2 Series IABP system minimum of 2 hours to a minimum of 4 hours. Includes cabling.
Fuse	4300-0002-0001	5 x 20 mm AC fuse rated at 6.3 ampere 250 Volt.
<b>MISCELLANEOUS</b>		
AutoCAT™2 SERIES Pak	IAA-01003	Side mounting, clip on bag for manuals and accessory storage.
Covers for High Level Inputs system.	2800-9264003	Clear plastic covers for Input/Output jacks, to prevent dust and fluid ingress into the AutoCAT™2 Series IABP
FlashCard	IAA-09005	4 MB Flash Card

### **The AutoCAT™2 One-Year Limited Warranty**

Arrow International, Inc. (ARROW) warrants the ARROW AutoCAT™2 Intra-Aortic Balloon Pump against defects in materials and workmanship for a period of ONE (1) YEAR from the date of purchase. If ARROW receives notice of such defects during the warranty period, ARROW will, at its option for the original customer, repair or replace products which prove to be defective.

#### **Exclusions**

The above warranty shall not apply to defects resulting from: (a) repairs by an unauthorized party; (b) improper maintenance by the customer; (c) modifications made without written permission of ARROW; (d) damage by accident, abuse, misuse, or misapplication; (e) operation otherwise than in accordance with instructions furnished by ARROW; or (f) if the serial number has been altered, defaced or removed.

#### **Obtaining Warranty Service**

To obtain warranty service, please call Arrow International's Intra-Aortic Balloon Product Hotline 24 hours a day at 1-800-447-6961 or 1-617-389-8628 (outside the U.S.A. or Canada).

**THE WARRANTY AND REMEDIES SET FORTH ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHERS, WHETHER ORAL OR WRITTEN, EXPRESS OR IMPLIED. ARROW SPECIFICALLY DISCLAIMS ANY AND ALL IMPLIED WARRANTIES, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.** No ARROW dealer, distributor, agent or other person is authorized to make any modification, extension or addition to this warranty.

**ARROW IS NOT RESPONSIBLE FOR DIRECT, INDIRECT, SPECIAL, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.**

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**CHAPTER 7: Parts List**

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## **7. Parts List Section**

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## 7. Parts List Section

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**77-1000-001**  
**CPU PCB Assembly**

Ref Designator	Description	Qty	Part Number
BZ1	Piezo Audio Indicator	1	2200-9004-001
C107,108	.01uF Film CAP, 50V	2	1500-0000-033
C112	.001uF Ceramic Cap, 50V	1	1500-0000-024
C123-139,141,142,144	.001uF Ceramic Cap, 25V	20	1500-0000-023
C14	5pF, Ceramic chip, 50V	1	1500-0000-025
C15	15pF, Ceramic chip, 50V	1	1500-0000-027
C151	Capacitor, .1uf 20% Chip	1	1500-0000-055
C152	Capacitor, Film, 10nf, SMD, 10%	1	1500-0000-004
C16,17,140,143	20pF, Ceramic chip, 50V	4	1500-0000-028
C18,25,114,115	10uF, SM, Tant., 16V	4	1500-0000-035
C19,20,26,27	1uF, Ceramic chip, 25V	4	1500-0000-032
C1-C13,24	.01uF, Ceramic chip, 50V	14	1500-0000-029
C21	4.7 uF Ceramic Cap	1	1500-0000-050
C22,23,28,31-80,83,84, 87,91,92,94,99,105,106, 116,145-150	.1uF, Ceramic chip, 50V	69	1500-0000-031
C29,30	33pF, Ceramic chip, 50V	2	1500-0000-030
C81,82,89,90,97,98,102, 103,109,110,119-122	47uF, SM, Tant., 16V	14	1500-0000-034
C85	470uF, Aluminum, Elec., 16V	1	1500-0000-020
C86,88,95,96,100,101, 117,118	.22uF, Ceramic chip, 50V	8	1500-0000-026
C93,104,111	4700uF, Aluminum, Elec., 16V	3	1500-0000-019
D1, D8	LED Green Clear Lens	2	4800-9100-024
D2, D4, D6	LED Red Clear Lens	3	4800-9100-026
D3, D5, D7	LED Orange Clear Lens	3	4800-9100-025
DB1	Daughter Board Assembly	1	77-1080-001
FC1,2,7-29	Ferrite, 3A, 100 Ohms	25	2500-9300-020
FC3-6	Ferrite, 6A, 80 Ohms	4	2500-9300-019
J1	Header 4 x 2	1	2100-9142-001
J11	8 Pin Connector	1	2100-9300-024
J12	10 Pin Connector	1	2100-9300-023
J16-19	SM SOIC to PINS adaptor	4	2100-9300-031
J2,3,5	Header 5 x 2	3	2100-9142-002
J4	Header 32 x 2	1	2100-9142-003
J6	50 Pin Connector, AT50	1	2100-9116-001
J7	Header 2mm, 12 x 2	1	2100-9142-005
J8	6 Pin Connector	1	2100-9142-006
J9,10	2 Pin Connector	2	2100-9142-018
JP1-4	Mini Jump Shunt	4	2100-9008-002
JP1-4	Header 0.1" 2 Pin	4	2100-9300-006
PL-3	DB-9 Connector	3	2100-0643-001
P1W-P3W	Washer, #4 .060" Thick	6	2800-9500-006
Q1	NPN Darlington Transistor	1	4800-9100-023
Q2-4	N Channel MOSFET	3	4800-9100-005

## 7. Parts List Section

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### 77-1000-001 CPU PCB Assembly

Ref Designator	Description	Qty	Part Number
R10,13,14	1K, 5%, Thick Film Chip	3	4700-9200-106
R11,36-41,43,44,67-70	4.7K, 5%, Thick Film Chip	13	4700-9200-059
R12	820 Ohm SM Resistor 5%	1	4700-9200-092
R1-3,6	470 Thick film chip 5%	4	4700-9200-054
R15	2.2K, 5%, Thick Film Chip	1	4700-9200-060
R16	1K, 5%, Thick Film Chip	1	4700-9200-104
R17	3.3K, 5%, Thick Film Chip	1	4700-9200-061
R18	6.8K, 5%, Thick Film Chip	1	4700-9200-062
R19	8.2K, 5%, Thick Film Chip	1	4700-9200-063
R20	12K, 5%, Thick Film Chip	1	4700-9200-064
R21	10 Ohm 5% Thick	1	4700-9200-093
R23,25-30,55-62	1K, 5%, Thick Film Chip	15	4700-9200-053
R24	360 Ohm Thick film chip 5%	1	4700-9200-108
R31	10K 1% 1/4W	1	4700-9200-222
R34	200, 5%, Thick Film Chip	1	4700-9200-049
R4	10M, 5%, Thick Film Chip	1	4700-9200-051
R42	4.7K, 5%, Thick Film Chip	1	4700-9200-105
R5	330K, 5%, Thick Film Chip	1	4700-9200-052
R50	Resistor 4.99K 1%	1	4700-9200-009
R63	1.1 Ohm 1/2w 5% carbon film leaded	1	4700-9201-002
R65	100, 5%, Thick Film Chip	1	4700-9200-065
R7	7.5K Thick film chip 5%	1	4700-9200-107
R71	Resistor, 10m?, 5%	1	4700-9200-117
R72	Resistor, 100m?, 5%	1	4700-9200-118
R73	Resistor, 18m?, 5%	1	4700-9200-119
R8,9,22,32,33,35,45-49, 51-54	10K, 5%, Thick Film Chip	15	4700-9200-050
RN1	Resistor Network, 220 Ohms	1	4700-9200-066
SP1,2	Spacer #6	2	2800-9500-004
SW1	DIP Switch, 6 Pos, SM	1	5100-9100-009
TP1-5	Surface Mount Test point	5	3130-9000-026
U1	68332 Microcontroller	1	3130-0836-001
U10	Quad 2-Input OR Gate	1	3130-9000-024
U14,15	Octal Bus Transceiver	2	3130-9000-018
U17	3/5 RS232 Trans	1	3130-9000-031
U18	Quad 2-Input AND Gate	1	3130-9000-023
U19	Hex Inverter w / oc	1	3130-9000-013
U20	Quad SPST CMOS Analog Switch	1	3130-9000-015
U21	Graphic Processor	1	3130-0782-001
U22	Graphic Processor PAL	1	3130-0804-001
U23,24	Octal D TRANSP Latch	2	3130-9000-022
U26,27,31	Oct Bus Transceiver	3	3130-9000-019
U28,32	Octal Buffer / Line Driver	2	3130-9000-017
U3	1M NV Timekeeping RAM	1	3130-9000-011
U34	Socket for 8-Bit Microcontroller	1	2100-9300-025

## 7. Parts List Section

### 77-1000-001 CPU PCB Assembly

Ref Designator	Description	Qty	Part Number
U34	8-Bit Microcontroller	1	2100-9300-025
U35	Oscillator 40 Mhz	1	3130-9000-008
U36	DRAM	1	3130-0842-001
U37,38,41	Quad 2-1 Sel / Mux	3	3130-9000-025
U39,40	Dual D-Type Flip-Flop	2	3130-9000-012
U4	Quad UART	1	3130-0812-001
U45	Video RAM - TMS55165	1	3130-0844-001
U46	Oscillator 10Mhz	1	3130-9000-009
U47	Octal D-Type Flip-Flop	1	3130-9000-020
U48,49	Quad Diff Line Driver	2	3130-9000-026
U5	5/3 RS232 Trans.	1	3130-9000-030
U51	Octal TRANSP D-TYPE Latch	1	3130-9000-021
U6,7	Socket for 4 Meg EPROM	2	2100-9300-026
U6,7	4 Meg EPROM	2	2100-9300-026
U8,12,13,16,29	Octal Buffer / Line Driver	5	3130-9000-016
U9,25,42	Hex Schmitt-Trigger Inverter	3	3130-9000-014
XTAL1	20 Mhz	1	3130-9000-010
XTL1	3.6864 Mhz	1	2300-9100-003
XTL2	Quartz Crystal 32.768Khz	1	2300-9100-002
	Nylon Screw 4-40 x 1/2"	1	2800-9096-001
	Nylon Nut 4-40	1	2800-9096-002
	Screw 6-32 x .75" PH SEMS	1	2800-9433-001

### 77-1000-002 CPU PCB Assembly

1	CPU Bd	1	77-1000-001
2	Firmware Assembly U6	1	77-2010-001
3	Firmware Assembly U34	1	77-2011-001
4	Firmware Assembly U7	1	77-2014-001

## 7. Parts List Section

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**77-1010-001**

**Front End PCB**

Ref Designator	Description	Qty	Part Number
C1,2,4-6,10,13-16,20, 22,28,29,32,34-37,40, 42,44,45,46,49,52,56, 66,68,69,71,80,84,86, 88,91,93,94,95,100-102, 104-110,112,113,115,117, 118,121,122,124,127,128, 132,133,135,137,139,141, 143-147,149,151,153-156, 158,160,162,164-166,171, 177,179,180,181,182,184, 185,187,194,196,198,200, 204,205,207,208,215,219, 224,225,230-234,239,241, 243-245,248-250,253-257, 261-264,268-272,276-279, 283,235	Ceramic Chip .1uF	136	1500-0000-001
C103,285-287,288	Ceramic Chip 4.7nf SM	5	1500-0000-048
C11,247,260,275	Ceramic Chip 47pf SM	4	1500-0000-056
C126,136	Ceramic NPO Cap. 1000pF SM	2	1500-0000-005
C130,140	Ceramic chip Cap 4.7 NF SM	2	1500-0000-037
C138	Ceramic Cap. 470pF NPO SM	1	1500-0000-006
C167,178	Ceramic Chip .68uF SM	2	1500-0000-011
C18,98,251,265,280	Ceramic Cap. 10nF NPO SM	5	1500-0000-004
C188,190,201,203,206, 209-212,214,216,218, 220-C223	Ceramic Chip .01uF SM	16	1500-0000-014
C192,195	Ceramic Chip 22PF SM	2	1500-0000-046
C21,252,267,282	Ceramic NPO Cap. 2200pf SM	4	1500-0000-045
C217,213	Ceramic 2.2uF 16V SM	2	1500-0000-015
C26,39,58,59,81,82,85, 89,99,111,114,116,119, 120,123,125,134,148,150, 157,163,183,226,284	Tant. Chip 10uF 20V SM	24	1500-0000-018
C289,290	Ceramic Chip 33pF SM	2	1500-0000-016
C3,19,23,31,92	Ceramic Chip 22nf SM	5	1500-0000-003
C33,90,97,131,142, 159,170,176,186,197, 240,259,274	Ceramic Cap. 3.3nF NPO SM	13	1500-0000-008
C38,242,266,281	Ceramic Chip 330 pf NPO SM	4	1500-0000-047
C41,168,169,172,174,175	Ceramic Chip 1uF SM	6	1500-0000-012
C47,70	Tant. Chip 330uF 10V SM	2	1500-0000-044
C48	1uF Ceramic Cap	1	1500-0000-052
C7,8,12,17,24,25,27,30	Ceramic Chip 47pF 1% SM	8	1500-0000-049
C83,129,199,161	Ceramic Cap. 0.047uF SM	4	1500-0000-010
C9,189,191,202,227,246, 258,273	Tant. Chip 33uF 16V SM	8	1500-0000-017
C96,152,173,193	Ceramic Cap. 33nF SM	4	1500-0000-009

## 7. Parts List Section

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**77-1010-001**

**Front End PCB (continued)**

Ref Designator	Description	Qty	Part Number
CR1,12,19,24,27,30,33, 36,39	Dual Diode SM	9	4800-9100-015
CR2,13,20,25,28,31,34, 37,40	Diode SM	9	4800-9100-016
CR22, 23	Low leakage Diode SM	2	4800-9100-002
CR3,5-11,15-18	Low leakage Diode SM	12	4800-9100-003
CR41-44	Dual Diode SM	4	4800-9100-007
CR45	Schottky Diode SM	1	4800-9100-018
F1,2	Resettable Fuse	2	5100-9100-002
FC1-6	Ferrite, 3A SM	6	2500-9300-020
GAP1-5	Spark Gap	5	4700-9063-001
J1	8 Pin Right Angle Con Gold	1	2100-9300-002
J2	8 Pin Pocket Con	1	2100-9300-003
J3	5 x 2 2mm Header	1	2100-9300-009
J4	10 Pin Right Angle Con Gold	1	2100-9300-004
J5	15 x 2 2mm Header	1	2100-9300-020
J6	2mm Header 6 x 2 SM	1	2100-9300-021
J7	Header 0.1" Thru hole 3 Pin	1	2100-9300-005
J8	Header 0.1" Thru hole 2 Pin	1	2100-9300-006
JP8,9	Jumper .1" Pitch	2	2100-9008-002
Q1,7-9	JFET P Channel SM	4	5100-9100-003
Q2,3	P Channel MOSFET SM	2	3130-9000-034
Q4,5,11	MOSFET N Channel SM	3	4800-9100-001
Q6,10	MOSFET N Channel SM	2	4800-9100-017
R1,47,56,59,64,66,84, 108,115,131-133,142, 147,149,171,172,191, 228,229,231,232,240-242, 244,246,247,252,255,257, 274,275,277,281,284,285, 295,305,318,308,329	Resistor TF 10K 1% SM	42	4700-9200-003
R102,120	Resistor TF 22 1/4W 1% SM	2	4700-9200-025
R11,23,114,128,261,267, 287,297,311,320	Resistor TF 2.2M 1% SM	10	4700-9200-010
R110	Resistor TF 1.1K 0.1% SM	1	4700-9200-068
R12,19,38,50,51,53,60, 92,117,139,140,153,165, 173,176,187,190	Resistor TF 20K 1% SM	17	4700-9200-002
R124	Resistor TF 4.7 1/4W 5% SM	1	4700-9200-027
R125,112	Resistor TF 511 1% SM	2	4700-9200-028
R126,123	Resistor 1G Ohms	2	4700-4005-001
R127,154,158,164,167, 178,179,183,184,188,189, 192,196,204,205,206,209, 217,218,219,227,234,235, 238,239,226	Resistor TF 10 1/4W 5% SM	26	4700-9200-029
R13,R262,R290,R313	Resistor TF 8.66K 1% SM	4	4700-9200-077

## 7. Parts List Section

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**77-1010-001**

**Front End PCB (continued)**

Ref Designator	Description	Qty	Part Number
R134,174,175	Resistor TF 32.4K 1% SM	3	4700-9200-042
R14,22,25,29,32,39,49, 81,99,109,119,162,180, 233,263,266,291,296, 314,319	Resistor TF 100K 1% SM	20	4700-9200-008
R146	Resistor SM 0.10 Ohm 1% SM	1	4700-9200-101
R15,264,292,315	Resistor TF 6.04K 1% SM	4	4700-9200-082
R166	Resistor TF 9.53K 1% SM	1	4700-9200-098
R194,201	Resistor TF 40.2K 1% SM	2	4700-9200-033
R195,198	Resistor TF 301K 1% SM	2	4700-9200-034
R197,214,222	Resistor TF 475K 1% SM	3	4700-9200-035
R199,200	Resistor TF 110K 1% SM	2	4700-9200-036
R2,45,121,129,135,136, 137,138,143,144,151,155, 159,161,163,182,193,202, 207,215,248,253,258,279, 288,306,312	Resistor TF 49.9k 1% SM	27	4700-9200-004
R20,104,168,169,185, 265,293,316	20K Pot 11 Turn SM	8	4700-9200-001
R203,216,225	Resistor TF 221K 1% SM	3	4700-9200-038
R208	Resistor TF 249K 1% SM	1	4700-9200-039
R210	Resistor TF 332K 1% SM	1	4700-9200-083
R211,212	Resistor TF 66.5K 1% SM	2	4700-9200-032
R213	Resistor TF 10M 5% SM	1	4700-9200-041
R220,249	Resistor TF 11.8K 1% SM	2	4700-9200-047
R221	Resistor 3.83K 1%	1	4700-9200-116
R224	Resistor TF 2.94K 1% SM	1	4700-9200-074
R230	Resistor TF 787K 1% SM	1	4700-9200-071
R236,141	Resistor TF 27.5% SM	2	4700-9200-030
R237	Resistor TF 150K 1% SM	1	4700-9200-044
R24,150	Resistor TF 309K 1% SM	2	4700-9200-020
R243	Resistor TF 14.3K 1% SM	1	4700-9200-073
R250	Resistor TF 787 1% SM	1	4700-9200-111
R26,27,100,101,122,268, 269,298,299,321,322	Resistor TF 113K 1% SM	11	4700-9200-015
R271,302,325,328	Resistor TF 3.92K 1% SM	4	4700-9200-100
R28,270,301,324	Resistor TF 31.6K 1% SM	4	4700-9200-099
R3,21,34,48	Resistor TF 100M 1% SM	4	4700-9200-005
R30,62,63,160,272, 303,326,	Resistor TF 2K 1% SM	7	4700-9200-016
R31,82,86-88,273,304,327	Resistor TF 24.9K 1% SM	8	4700-9200-075
R33,65,67,111	Resistor TF 221 1/8W 1% SM	4	4700-9200-076
R330-333	Resistor 6.8K 1/4 W 1% SM	4	4700-9200-096
R4,68,69,71	Resistor TF 5.62K 1% SM	4	4700-9200-006
R40,41,54,97,98,116,148, 152,156,157,170,181,223	Resistor TF 1K 1% SM	13	4700-9200-017

## 7. Parts List Section

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**77-1010-001**

**Front End PCB (continued)**

Ref Designator	Description	Qty	Part Number
R46,55,130,145,251,254, 280,294,307,317	Resistor TF 200 Ohm 1% SM	10	4700-9200-070
R5,16,35,42,52	Resistor Comp 10K 1/4W 1% with 1W Option B SM	5	4700-9200-110
R6,7,17,18,36,37,43,44, 57,58,77	Resistor TF 681K 1% SM	11	4700-9200-103
R61,256,300,323	Resistor TF 619K 1% SM	4	4700-9200-102
R70,85,107,245,276,278, 286,289	Resistor TF 2.21K 1% SM	8	4700-9200-021
R72-75,83	Resistor Zero Ohm SM	5	4700-9200-037
R76,80	Resistor TF 4.22K 1% SM	2	4700-9200-011
R78	Resistor TF 8.45K 1% SM	1	4700-9200-045
R79	Resistor TF 6.34K 1% SM	1	4700-9200-046
R8,259,282,309	Resistor TF 4.02K 1% SM	4	4700-9200-080
R9,260,283,310	Resistor 402K TF 1% SM	4	4700-9200-079
R91	Resistor TF 82.5K 1% SM	1	4700-9200-072
R93	Resistor TF 620 0.1% SM	1	4700-9200-097
R95,103,106	Resistor TF 22.1K 1% SM	3	4700-9200-023
RV1-4	ESD protection SM	4	4800-9100-004
SIP2, SIP1	4.7K 10 Pin SIP	2	4700-9200-048
SO1	IC Socket 8 Pin Tin Contact	1	2100-9300-029
U18,21,23,32,48,81,83	Opto Isolator	7	3700-9000-001
U19,46,89	8 Channel Serial ADC SM	3	2000-9025-003
U2,38,45	Dual Op-Amp JFET SM	3	1100-0100-001
U20,33,49,71	Opto Isolator	4	3700-9000-002
U25,27,41	-5 Voltage Reg. SM	3	4000-9100-002
U26	+5 V Reg SM	1	1100-0100-008
U3	Single Op-Amp JFET SM	1	1100-0100-002
U34	Opto Isolator	1	3700-9000-003
U36,53,75	Op-Amp High Current SM	3	1100-0100-005
U37,60	+5V Voltage Ref. SM	2	5500-9100-001
U39	DC/DC Power Supply	1	4000-9100-001
U40,42,68	+5 V Reg SM	3	4000-9100-003
U43,44,47	Dual Op-Amp JFET SM	3	1100-0100-006
U50	12-Bit Serial DAC SM	1	2000-9025-004
U56	44 pin PLCC Socket	1	2100-9117-001
U56 PROGRAMMABLE PART	Unprogrammed ROM	1	3130-0838-002
U58	RS232 Driver SM	1	1900-0000-001
U6,11,13,16,29,51,59,62	Inst. Amplifier SM	8	1100-0100-003
U61,66	Hex Inverter SM	2	4000-9100-004
U63	Quad NAND Gate SM	1	3130-9000-032
U64	5 Volt Reference	1	3130-9000-048
U65	32 Bit Microcont. SM	1	3130-0836-001
U67	P-Channel Switch SM	1	5100-9100-004

## 7. Parts List Section

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**77-1010-001**

**Front End PCB (continued)**

Ref Designator	Description	Qty	Part Number
U69 PROGRAMABLE PART	Unprogrammed PIC12C508 Microcontroller	1	3130-9000-004
U7,9,77,78,84-86,88	Op-Amp SM	8	1100-0100-007
U70	Reset IC SM	1	3130-9000-002
U73	Opto Coupler	1	3130-9000-001
U76	SRAM 32x8 SM	1	3130-9000-029
U8,10,31,52,54,55,57,72, 74,79,80,82,87	Op-Amp Low power SM	13	1100-0100-004
X1	Crystal 32.768KHZ SM	1	2300-9100-001
X2	20.000 MHZ Crystal SM	1	3130-9000-010
	Blank PC Board	1	77-1012-001

Note: Jumper pins 1 & 2 of J7 with JP9

Jumper pins 1 & 2 of J8 with JP8

**77-1010-002**

**Front End PCB Assembly**

1	Front End Bd	1	77-1010-001
2	Firmware Assembly U56	1	77-2012-001
3	Firmware Assembly U69	1	77-2015-001

**77-1100-001**

**I / O PCB Assembly**

C1-3	Capacitor 0.1 uF 50V Cer	3	1500-9027-014
JP1	20 Pin Connector MLX 39-29-0203	1	2100-9206-005
JP2	2 Pin Connector MLX 39-29-0023	1	2100-9206-004
JP3	10 Pin Connector AMP 104128-1	1	2100-9206-007
JP4	2 Pin Connector AMP 103735-1	1	2100-9206-006
Lug	Ring Lug AMP 8-53941-1	1	2100-9039-005
PJ1-6	1/4" Phone Jack L114BPC	6	2100-9047-002
Q1	N MOSFET VN10LP	1	4750-9008-006
R1,4,5	Resistor 1K 1/4 Watt 1%	3	4700-9001-301
R2,3	Resistor 1.5K 1/4 Watt 1%	2	4700-9001-318
R6	Resistor 30.1K 1/4 Watt 1%	1	4700-9200-115
RV2,3,8,9	Transorb 1.5KE11CA	4	4800-9100-011
TY-WRAP	5 1/2" Long	1	6000-0051-001
Wire	Wire, Green / Yellow 16 AWG	AR	6000-9004-014
	PC Board	1	77-1102-001

## 7. Parts List Section

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**77-1110-001**

**5 / 12 Volt Alarm PCB Assembly**

Ref Designator	Description	Qty	Part Number
D1,3,4	DIODE	3	4800-9020-001
D2	2.5V REF DIODE	1	4800-9100-028
F1	FUSE	1	4300-9000-001
J1	2 PIN CONNECTOR	1	2100-9300-035
J2	3 PIN CONNECTOR	1	2100-9300-036
LS1	ALARM SOUNDER	1	2200-9004-001
R1,2	330 OHM 1/2W 5%	2	4700-9200-220
	ALARM PCB	1	77-1112-001

**77-3000-001**

**AutoCAT™2 Series IABP Assembly**

1	Weldment: Frame Assembly	1	96-3000-002
2	Caster: 5" Hardwheel w / lock	4	1400-9043-001
3	Nut: Hex 1/2-13	AR	2800-9077-031
4	Washer: Split Med. Steel 1/2"	AR	2800-9299-001
5	Washer: Flat 1/2"	AR	2800-9055-112
11	Assembly: Raise & Lower Mechanism	1	77-3014-001
12	Pump Assembly	1	77-3200-001
13	Screw: SH 10-32 x .750"	AR	2800-9161-417
15	Nut: Keps 8-32	AR	2800-9073-005
16	Screw: PH PHL 8-32 x 1/2"	AR	2800-9007-113
17	Speaker: Micro	1	1300-9001-001
18	Polyurethane Foam: 1" x 1"	1	1600-9002-007
19	Screw: Torx Flat MS SS M3 x 10mm	AR	2800-9295-004
20	Locite Super Bonder: 414	AR	1600-0050-001
22	Latch: Rotation Assembly	1	96-0026-001
23	Spring: Torsion .040" x .187"	1	2500-9064-011
24	Pin: Roll 1/8" x 1.25"	1	2500-9079-001
25	Washer: Latch Plate	AR	2800-9291-001
26	Screw: PH PHL 8-32 x .375" w / patch	AR	2800-9306-001
27	Washer: Split Lock #8	AR	2800-9057-109
28	Tank Pivot	1	77-0021-001
29	Washer: Ext. Tooth #8	AR	2800-9075-109
31	Bracket: Latch	1	96-0027-002
32	Battery: 12V 20AH	1	4000-9022-002
33	Bracket: Battery Hold Down	1	96-0019-001
34	Bracket: Battery	1	96-0018-001
38	Washer: Flat #8	AR	2800-9055-105
39	Clamp / Screw Assembly: Power Cord	1	96-0103-001
40	Power Supply AC/DC	1	77-0063-001
42	Washer: Flat #10	AR	2800-9055-106
43	Washer: Split Lock #10	AR	2800-9057-112
51	Cable: Power Supply	1	96-3704-001

## 7. Parts List Section

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**77-3000-001**  
**AutoCAT™2 Series IABP Assembly (continued)**

Ref Designator	Description	Qty	Part Number
52	Clamp: Clip Dek	1	6000-9020-004
55	Assembly: Side Panel	1	77-3009-001
56	Front Panel Assembly	1	77-3008-001
57	Assembly: Display Head	1	77-3016-001
58	Battery Circuit Breaker Cable	1	77-3734-001
59	Cable: Display Head	1	96-3701-001
60	Regulator Assy. Helium	1	77-3007-001
61	Top Cover	1	77-0001-001
62	Right Side Cover	1	77-0002-003
64	Screw: PH PHL 8-32 x 5/16"	AR	2800-9007-107
66	Grip: Side Handle	2	96-0001-002
67	Cable: Recorder	1	96-3715-001
69	Washer: Wave .375" x .265"	AR	2800-9285-013
73	Recorder Assembly	1	3000-9006-001
74	Handle: Front (rubber covered)	1	96-0008-001
75	6 Amp Filter	1	5100-0102-002
76	Screw: PH PHL 8-32 x .750"	AR	2800-9007-117
79	Spacer: 6-32 Female x .375" long	AR	2800-9180-004
81	Shield Housing: Front End	1	77-0066-001
82	Front End Bd With Software	1	77-1010-002
83	CPU Bd With Software	1	77-1000-002
84	Cable: FE Bd / PS / Modem / FOS	1	77-3725-001
86	Cable: CPU / FE / FOS	1	77-3726-001
87	Cable: FE / CPU (inside housing)	1	77-3718-001
88	Cable: FE / IO (inside housing)	1	77-3720-001
89	Cable: FE / PS (inside housing)	1	77-3719-001
90	Cable: PS / CPU	1	96-3724-001
91	Cable: Valve Interface / CPU / PS	1	77-3713-001
95	Connector Mounting Kit	AR	2800-9263-001
98	Screw: PH PHL 6-32 x .312"	AR	2800-9006-107
99	Washer: Int. Tooth #6	AR	2800-9063-037
100	Label: Serial Number	AR	77-4011-001
102	Assembly: Ball Chain & Wing Nut	1	96-0075-001
104	Cable: Speaker	1	96-3731-001
105	Label: DC Fuse	1	96-4001-001
106	Label: AC Fuse	1	77-4002-001
107	Cover: Connector 9 Pin	AR	2800-9264-002
108	Fuse: 6.3A 5 x 20mm, 250V, SB	2	4300-0002-001
111	Bottle: Water Collection	1	90-0845-001
112	Label: Field Change Level	1	96-4008-001
113	Label: Caution Static Sensitive Parts	1	96-4004-001
114	Label: Label: Battery	1	96-4005-001
115	Label: Proper Grounding	1	96-4007-001
116	Label: Danger Explosion Hazard	1	96-4006-001

## 7. Parts List Section

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**77-3000-001**

**AutoCAT™2 Series IABP Assembly (continued)**

Ref Designator	Description	Qty	Part Number
117	Label: Caution	2	96-4009-001
118	Label: Equipotentiality	1	96-4010-001
119	Label: Caution Use Helium	1	96-4003-001
120	Bushing for Side Panel	1	2500-9075-002
121	Stud: Hold Down	AR	2800-9245-001
122	Nut: Hex 3/8-24	AR	2800-9077-034
123	Stud: Equipotentiality	AR	2800-9290-001
124	Screw: PH PHL 8-32 x 1.125" SS	AR	2800-9007-123
125	Bushing: Tube Guide	2	96-0028-001
126	Screw: PH PHL 6-32 x .375"	AR	2800-9006-109
128	Screw: PH PHL 4-40 x .187"	AR	2800-9005-103
129	Washer: Split Lock #4	AR	2800-9057-105
130	Foam Strip: 1" x 18" x 3/32"	2	1600-9002-001
131	Screw: FH PHL 6-32 x .5" w / patch	AR	2800-9305-002
132	Grommet Strip	AR	2800-9103-002
133	Tubing: Tygon Clear 5/16" OD x 3/16" ID	AR	3100-0015-001
134	Cable Tie: 5.5"	AR	6000-0051-001
135	Tubing: PVC Clear 3/16" OD x 1/16" ID	AR	3100-0046-001
136	Screw: Socket Hd 8-32 x .562"	AR	2800-9161-314
138	Clamp: Clip Dek 3/8"	5	6000-9020-005
139	Washer #8	AR	2800-9303-001
140	Plate Mount: Diamond 9# Red-Green	2	2500-9087-001
141	Plate Mount: Diamond 14# Green-Blue	2	2500-9087-002
142	Screw: Socket Hd 10-32 x 1.250"	AR	2800-9161-425
143	Screw: Skt Hd Sh .2495" Dia. X .625"	2	2500-9069-003
144	Screw: PH PHL 6-32 x .250"	AR	2800-9006-105
145	Washer: #10	AR	2800-9303-002
148	Ground Cable: Chassis	1	96-3732-001
149	Label: Battery	2	99-4038-001
150	Clamp: Plastic Sleeve Tubing	2	2500-9080-004
151	Screw: PH PHL 6-32 x .5" w / patch	AR	2800-9309-001
153	Bracket: Hold Down Power Cord	1	96-0097-001
154	Washer: Split Lock #6	AR	2800-9057-107
155	Cable: ECG (inside housing)	1	77-3708-002
156	Cable: Art. Press. (inside housing)	1	77-3709-002
157	Screw: 6-32 x .250" Nylon Reinforced	AR	2800-9304-002
158	Standoff: 1/4 Hex, 6-32 x .750"	AR	2800-9135-005
159	Modem Module 56K	1	2000-0001-001
160	Cable: Modem / CPU	1	96-3736-001
161	Clamp: Plastic Hose .351"	1	2500-9080-008
164	Standoff: M / F 10-32 x 3/4"	AR	2800-9310-002
165	Screw: PH PHL 4-40 x 5/16"	AR	2800-9005-107
166	Screw: FH PHL 6-32 x .375" 100 Deg.	AR	2800-9009-109
167	Clamp: Cable Nylon	3	2500-9071-001

## 7. Parts List Section

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**77-3000-001  
AutoCAT™2 Series IABP Assembly (continued)**

Ref Designator	Description	Qty	Part Number
168	Plug for Skt Hd Screw SH-31	AR	2800-9264-003
169	IMS Motor Driver Assembly	1	77-3018-001
170	Clamp Clip Dek	2	6000-9020-002
171	Washer: Alum. .215" x .392" x .050"	AR	2800-9312-001
172	Cable: Flash Card Interface	1	77-3710-001
174	Adhesive: Medium Strength	AR	1600-0084-001
175	Washer: Nylon .140" x .312" x .010"	AR	2800-9311-001
176	Washer: Nylon .140" x .312" x .050"	AR	2800-9311-002
177	Cable Ties 8"	1	6000-9037-001
178	Bushing Side Panel	1	96-0107-001
179	Ferrite Clamp	1	2100-9170-001
182	Washer Nylon .140" x .312" x .040"	AR	2800-9311-004
183	Grounding Plate	1	96-0109-001
185	Washer: Curved Disc Spring	AR	2800-9085-014
186	Screw PH PHL 6-32 x .875"	AR	2800-9006-119
187	Washer: Flat #6	AR	2800-9055-104
188	Lock Nut 6-32 (ESNA)	AR	2800-0120-001
189	FOS Cooling, Lower Shroud	1	77-3023-001
190	Screw: FH PHL 4-40 x .375"	AR	2800-9012-109
191	5 / 12 Volt Alarm Bd Assembly	1	77-1110-001
192	Screw: FH PHL 4-40 x 1/4"	2	2800-9012-105
193	Nut: Keps 4-40	AR	2800-9073-001
194	Augmentation Chamber	1	4500-9100-004
196	Clamp: Cable 1-1/8" Nylon	1	2500-9071-002
197	Screw: FH PHL 8-32 x .250"	AR	2800-9010-105
198	Augmentation Valve Assemby	1	77-3024-001
199	Screw: FH PHL 6-32 x .5"	AR	2800-9002-113
200	FOS Bd	1	77-1070-002
201	Screw: PH PHL 4-40 x .5"	AR	2800-9005-113
202	Washer: Int. Tooth #4	AR	2800-9063-036
203	FOS Cooling, Upper Shroud	1	77-3002-001
205	3/16" Tube Wyes	1	2500-9300-026
206	Tubing Tygon 1/8" ID X 1/4" OD	AR	3100-9100-004
207	Tubing 3/8" ID x 1/2" OD Poly Lined PVC	AR	3100-9101-001
208	Cable: FE / BP / HEL / Front Panel	1	77-3712-001
209	Cable: FE / Transducer (inside housing)	1	77-3745-001
210	Cable: FE / Transducer (outside housing)	1	77-3746-001
211	Cable: Valve Interface 1 / CPU	1	77-3747-001
212	Washer Flat #4 .06 THK.	AR	2800-9065-001
213	Connector Mtg Kit 4-40 Metal Shell	AR	2800-9263-002
214	Connector Mtg Kit 4-40 Plastic Shell	AR	2800-9263-003
216	Label: Protective Earth	1	77-4001-001
217	Ferrite Snap On Block	1	2500-9063-005
218	Screw: Panel blue 6-32 x 1/2"	AR	2800-9304-005

## 7. Parts List Section

### 77-3000-001

#### AutoCAT™2 Series IABP Assembly (continued)

Ref Designator	Description	Qty	Part Number
219	Plate Side Panel	1	77-0080-001
220	Shield Strip, Fabric, .67"H x .59"W x 9"L	4	2500-9284-005
221	Shield Strip, Fabric, .08"H x .27"W x 18)L	2	2500-9284-006
222	Shield Strip, Fabric, .04"H x .16"W x 20)L	2	2500-9284-007
223	Shield Strip, Metal, .13"H x .37"W x 2)L	4	2500-9284-008
224	Shiled Strip, Metal, .13"H x .37"W x 15)L	2	2500-9284-009
225	Shield Strip, Metal, .22"H x .6"W x 14)L	2	2500-9284-010
226	Spiral Wrapping	AR	3100-9041-001
227	Screw: FH PHL 8-32 x .625"	AR	2800-9010-115
228	Braid Reinforced PVC Tubing	AR	3100-9035-001
229	Label: ETL US / Canada	1	77-4012-001
231	Standoff, 4-40 x 3/8" Nylon	2	2800-9074-002
232	Screw: PH PHL 4-40 x .250"	2	2800-9005-105
233	Lift Handle Assembly	2	96-3150-001

### 77-3001-001

#### FOS Connector

1	Track FOS Connector	1	77-0009-001
2	Bracket, FOS Receptacle Mount	1	77-0039-001
3	Flapper Door	1	77-0006-001
4	Door Brace	1	77-0007-001
5	Screw: FH PHL 6-32 x .375" 100 Deg	AR	2800-9009-109
6	Screw: PH PHL 4-40 x .250"	AR	2800-9005-105
7	Washer: Split Lock #4	AR	2800-9057-105
8	Screw: PH PHL 2-56 x .250"	AR	2800-9004-105
9	Washer: Split Lock #2	AR	2800-9057-103
10	FOS Adapter w / Membrane	1	2100-9300-027

### 77-3002-001

#### FOS Cooling, Upper Shroud

1	Shroud	1	77-0029-001
2	Thermostat (FOS Cooling)	1	5300-9000-001
3	Screw, PH Self Tap 4.24 x 1/4"	AR	2800-9300-021
4	Washer: Flat #4	AR	2800-9055-103
5	Receptacle: Mini Fit 2 pin	1	2100-9147-010
6	Terminal: Crimp Female (18-24 AWG)	2	2100-9147-007

## 7. Parts List Section

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**77-3007-001**

### Helium Regulator Assembly

Ref Designator	Description	Qty	Part Number
1	Tank Pivot Bracket	1	77-0015-001
2	Helium Regulator Assembly	1	96-0074-001
3	Helium Pressure Xducer Assy	1	96-3013-001
4	Swell Latch	1	2500-0173-001
6	Screw: PH PHL 6-32 x .5"	AR	2800-9006-113
7	Washer: Flat #6	AR	2800-9055-104
8	Washer: Int. Tooth #6	AR	2800-9063-037
10	Tape Teflon 1/2"	AR	3100-0036-001
13	Elbow: Street 1/8M x 1/8F	1	2500-9002-103
14	Tape Teflon 1/4"	AR	3100-0036-002
15	Cable Tie: 5.5"	AR	6000-0051-001

**77-3008-001**

### Front Panel Assembly

1	Front Panel Cover	1	77-0003-001
2	Bracket: Recorder	1	96-0023-001
3	Flashcard Faceplate	1	77-0024-001
4	Bracket: Flash Card	1	96-0025-001
5	Bracket: Connector Mounting	1	96-0053-001
6	Assembly: Flash Card Interface	1	96-1040-001
7	Assembly: Interface Block	1	77-3012-001
8	Cable: Data Out RS232	1	96-3705-001
9	Cable: ECG	1	77-3708-003
10	Cable: Art. Press. (outside housing)	1	77-3709-003
11	Cable: Modem / Front Panel	1	96-3735-001
14	Led: Green	1	2450-1014-001
15	Led: Yellow	1	2450-1014-002
16	Insert: Sheet Edge	4	2500-9076-001
17	Washer: Flat Fiber, #6	AR	2800-0171-001
18	Screw: PH PHL 6-32 x .5"	AR	2800-9006-113
19	Screw: Panel blue	AR	2800-9304-004
20	Screw: PH PHL 8-32 x 5/16"	AR	2800-9007-107
21	Screw: PH PHL 8-32 x .375"	AR	2800-9007-109
22	Washer: Flat #2	AR	2800-9055-102
24	Washer: Split Lock #2	AR	2800-9057-103
26	Washer: Split Lock #8	AR	2800-9057-109
27	Nut: Keps 6-32	AR	2800-9073-003
28	Nut: Hex 2-56	AR	2800-9077-101
32	Switch: Illuminated	1	5100-9009-006
33	Label Set	1	77-4000-001
35	Cable Assy: Ground Strap 4.5"	2	96-3727-001
36	Bracket: Shield Connector Housing	1	77-0053-002
37	Cable: Ground Strap 15"	1	96-3729-001

## 7. Parts List Section

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**77-3008-001**

**Front Panel Assembly (continued)**

Ref Designator	Description	Qty	Part Number
38	Cable: Front Panel Switch & LEDs To PS	1	77-3716-001
39	Assembly: Fan I/O Panel	1	77-3015-001
40	Fan Guard	1	1400-0000-001
45	Connector Mtg Kit	AR	2800-9263-001
46	Locite Super Bonder: 414	AR	1600-0050-001
47	Clamp Cable	2	2500-9080-005
50	Cable: I/O Board To Front Panel	1	77-3748-001
51	Cable: FOS Board Calibration Key	1	77-3749-001
52	DATAKEY Receptacle	1	2100-9300-028
53	FOS Connector Sub-Assembly	1	77-3001-001
54	I/O Bd	1	77-1100-001
55	Latching Block	AR	2100-9210-001
56	Screw: Socket Hd 4-40 x .5" SS	AR	2800-9161-113
57	Screw: PH PHL 6-32 x 1.250"	AR	2800-9006-125
58	Washer: Ext. Tooth #6	AR	2800-9075-107
59	Grommet Strip	AR	2800-9103-002
60	Screw: FH PHL 6-32 x .250" 82 Deg.	AR	2800-9002-105
61	Cable Tie: 5.5"	AR	6000-0051-001
62	Cable Tie: 9.7" x .142"	AR	6000-0051-002

**77-3009-001**

**Left Side Panel Assembly**

1	Helium Door	1	77-0004-002
3	Cable: CPU / Display	1	96-3703-001
4	Elapsed Time Meter	1	2200-0005-001
5	Catch: Magnetic Snap In	1	2500-0173-002
6	Strike: Steel	1	2500-0173-003
7	Hinge for Tank Door	2	2500-9067-001
8	Bushing for Side Panel	1	2500-9075-002
9	Screw: Allen Cap, 8/32 x .5"	AR	2800-0100-001
10	Screw: FH PHL 8/32 x .5"	AR	2800-9003-113
11	Washer: Split Lock #8	AR	2800-9057-109
12	Screw: PH PHL M2.5 x 12mm	AR	2800-9295-001
13	Nut: Keps 6-32	AR	2800-9073-003
14	Side Cover: Left Side	1	77-0002-001
15	Washer: Flat Rubber #8	AR	2800-9059-307
16	Ground Cable: Time Meter	1	96-3723-002
17	Washer: Int. Tooth #4	AR	2800-9063-036
20	Bracket: Time Meter Display	1	77-0102-001
21	Nut: Keps 4-40	AR	2800-9073-001
23	Circuit Breaker	1	4300-0003-001
25	Bushing Side Panel	1	96-0107-001
26	Clamp: Hinged Flat Cable	1	2500-9080-003

## 7. Parts List Section

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**77-3009-001**

### Left Side Panel Assembly (continued)

Ref Designator	Description	Qty	Part Number
27	Cable: Time Meter	1	96-3724-002
28	Screw: PH PHL 6-32 x .375"	AR	2800-9006-109
29	IV Pole Bracket	1	96-0101-001
32	Screw: PH PHL 6-32 x .312"	AR	2800-9006-107
33	Cable: Circuit Breaker	1	96-3733-001
34	Clamp: Cable - SST2M	1	6000-0109-001
35	Switch Guard	1	96-0098-001
36	Foam Strip: 1" x 18" x 3/32"	1	1600-9002-001
37	Tubing: Heat Shrink 1/8"	AR	3100-0007-001
38	Adhesive: Medium Strength	AR	1600-0084-001

**77-3012-001**

### Interface Block Assembly

1	Interface Block Sub Assembly	1	96-0077-001
2	Pin: Interface Block	2	10-0238-001
3	Fastener: Tinnerman	AR	2800-0069-001
4	Front Panel Balloon Connector Cable	1	77-3721-001
5	Tubing: Heat Shrink 1/8"	AR	3100-0007-001
6	Tubing: Polyflo (44P)	AR	3100-0083-001
7	Sealant: BiPax / TraBond	AR	1600-9025-001
8	Union: Tube to Tube 1/4 OD	1	2500-9047-004
9	Ferrule 1/4 Tube	1	2500-9063-004
10	Tube Nut, 1/4 Tube OD	1	2500-9062-004

**77-3014-001**

### Raise and Lower Mechanism

2	Ring: Retaining Steel	2	2500-9072-001
3	Bearing	1	2500-9066-001
4	Spike: Pivot	1	96-0031-001
5	Collar: Clamp-tite 1/2" ID	1	2500-9078-001
7	Washer: Split Lock #8	AR	2800-9057-109
9	Plug: Tube	1	96-0030-001
10	Screw: PH PHL 8-32 x 5/16"	AR	2800-9007-107
11	Screw: PH PHL 4-40 x 5/16"	AR	2800-9005-107
13	Screw: FH PHL 6-32 x .375" 100 Deg.	AR	2800-9009-109
14	Hinge Plate	1	96-0055-001
15	Screw: Set 4-40 x 1/8"	AR	2800-9231-101
16	Dowel Pin: .093" Dia x 5/8"	AR	2800-9267-003
17	Screw: Set 2-56 x 3/16" SS	AR	2800-9231-002
18	Locking Plate	1	96-0056-001
19	Locking Plate Top	1	96-0056-002
20	Plate: Brake Leveling	1	96-0072-001

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## 7. Parts List Section

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**77-3014-001**

**Raise and Lower Mechanism (continued)**

Ref Designator	Description	Qty	Part Number
21	Screw: Sh 6-32 x .156" x .3125" w / patch	2	2500-9069-004
23	Spacer: Pivot Spike	1	96-0073-001
24	Cable: Display Column	1	96-0062-001
25	Pin: Clevis .250" x 1.750"	1	2500-9065-005
26	Cradle	1	96-0032-001
27	Spring: Extension Neg - 10.6 lb	1	2500-9064-006
28	Mandrel	1	96-0051-001
29	Pin: Hairpin Cotter SS 1/4" x 5/16"	1	2500-9065-007
30	Extrusion: Tube	1	96-0029-001
32	Bottom Handle	1	77-0085-003
36	Clamp: Cable Nylon	1	2500-9071-001
38	Cable Link Left	1	96-0033-002
39	Cable Link: Right	1	96-0033-001
40	Spring: Extension .094" x 1.0"	2	2500-9064-010
41	Handle Release Button	2	77-0036-001
43	Screw: PH PHL 4-40 x .375"	AR	2800-9005-109
44	Washer: Shoulder #4 Nylon	AR	2800-9292-002
46	Lock Nut 6-32 (ESNA)	AR	2800-0120-001
48	Screw: FH PHL 2-56 x .375" w / patch	AR	2800-9013-209
50	Washer: Int. Tooth #4	AR	2800-9063-036
51	Washer: Flat SS 7/16"	AR	2800-9055-111
52	Washer: Split Lock 7/16"	AR	2800-9057-123
53	Screw: Hex 7/16-14 x .750"	AR	2800-9300-002
54	Screw FH PHL 6-32 x .875"	AR	2800-9009-119
55	Washer: Shoulder #2 Nylon	AR	2800-9292-004
56	Spring: Compression .60" x .045" x 1.25"	1	2500-9064-015
57	Adhesive: Medium Strength	AR	1600-0084-001
58	Cradle: Top	1	96-0032-002
59	Spacer: Spring Retainer	1	96-0030-002
62	Pin: Display Head Locating	2	96-0046-001
63	Pivot Front	1	77-0083-001
64	Pivot Back	1	77-0083-002
65	Connector: Hinge	2	96-0084-001
66	Cord Wrap	1	77-0089-001
67	Washer: Display Head Locking	1	96-0091-001
68	Easel Panel Liner	1	77-0092-001
69	Screw: FH PHL 8-32 x .250"	AR	2800-9010-105
70	Screw: PH PHL 8-32 x .375"	AR	2800-9007-109
71	Screw: PH PHL 8-32 x 1/2"	AR	2800-9007-113
72	Screw: PH PHL 8-32 x .625"	AR	2800-9007-115
73	Washer: Ext. Tooth #3	AR	2800-9075-109
74	Hinge: Left (Display Hd)	1	2500-9089-001
75	Hinge: Right (Display Hd)	1	2500-9089-002
76	Display Top Handle	1	77-0085-001

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## 7. Parts List Section

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**77-3014-001**

**Raise and Lower Mechanism (continued)**

Ref Designator	Description	Qty	Part Number
77	Knob	1	96-0087-001
78	Screw: FH PHL 8-32 x .750"	AR	2800-9010-117
79	Screw: PH PHL 8-32 x .875"	AR	2800-9007-119
80	Washer Nylon .260" x 1.437" x .031"	AR	2800-9311-003
81	Locite Super Bonder: 414	AR	1600-0050-001
82	Solution Sprayon	AR	16-0097-001
83	WD-40 Lubricant	AR	1600-9024-001
84	Washer: Aluminum, .215" x .392" x .050"	AR	2800-9312-001
85	Screw: PH PHL 6-32 x .375"	AR	2800-9006-109
86	Washer: Int. Tooth #6	AR	2800-9063-037
87	Nut: Keps 6-32	AR	2800-9073-003
88	Raise / Lower Mechanism Ground Strap	1	96-3740-001

**77-3015-001**

**Fan Assembly, Front Panel**

1	Fan	1	5700-0000-002
3	Receptacle: Mini Fit 2 pin	1	2100-9147-010
4	Terminal: Crimp Female (18-24 AWG)	2	2100-9147-007

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**77-3016-001**

**Display Head Assembly**

1	Keypad Assembly	1	77-0037-002
2	Screw: Set SS 6-32 x .875"	AR	2800-9016-130
3	Latch	1	77-0088-001
4	Bracket: Display Hold Down	1	96-0090-001
5	Spring: Display Latch	1	96-0093-001
6	Cable: Keyboard / Display	1	96-3702-001
7	Cable: Power Invertor / Kbd Cont	1	96-3706-001
8	Cable: Interface Kybd Cont / Display	1	96-3707-001
9	LCD Module	1	2450-9017-001
10	LCD Invertor	1	2450-9017-002
12	Grommet LCD Mounting Plate	4	2500-9070-001
13	Rivet: Pop .125" Dia	AR	2800-9115-002
14	Washer: Latch Plate	AR	2800-9291-001
15	Screw Plastic 4-40 x .5"	AR	2800-9096-001
16	Screw: PH PHL 4-40 x .5"	AR	2800-9005-113
18	Screw: PH PHL 6-32 x .5"	AR	2800-9006-113
19	Screw: PH PHL 8-32 x .250"	AR	2800-9007-105
20	Screw: PH PHL 8-32 x .5"	AR	2800-9007-113
21	Washer: Ext. Tooth #8	AR	2800-9075-109

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## 7. Parts List Section

77-3016-001

### Display Head Assembly (continued)

Ref Designator	Description	Qty	Part Number
22	Washer: Flat #6	AR	2800-9055-104
23	Washer: Flat #8	AR	2800-9055-105
24	Washer: Int. Tooth #4	AR	2800-9063-036
25	Nut: Keps 6-32	AR	2800-9073-003
29	Screw: PH PHL M2.5 x 12mm	AR	2800-9295-001
30	Display Front Cover	1	77-0082-001
31	Display Rear Cover	1	77-0082-002
32	Cable: Ground Strap Cont Mod	1	96-3711-001
33	Display Bracket	1	77-0040-001
34	Nut: Hex M2.5	AR	2800-9296-001
35	Washer: Flat M2.5	AR	2800-9298-001
36	Screw PH PHL 2-56 x .250"	AR	2800-9004-105
37	Pad Display Housing	1	96-0106-001
38	Kapton Tape 1" Wide	AR	3100-9037-001
39	Nut Plastic Hex 4-40	AR	2800-9096-002
40	Spacer Nylon #4 3/16" Long	AR	2800-9096-003

77-3018-001

### IMS Driver Assembly

1	IMS Motor Driver Module	1	2000-9000-003
2	Cable IMS / Motor / PS	1	77-3737-001
3	Cable IMS Motor Driver / CPU	1	77-3738-001
4	Bracket IMS Motor Driver	1	96-0099-001
7	Thermal Pad	1	5300-0004-001
8	Screw: PH PHL 8-32 x 1.5"	AR	2800-9007-127
10	Adhesive: Medium Strength	AR	1600-0084-001
12	Washer #8	AR	2800-9303-001
13	Washer: Split Lock #8	AR	2800-9057-109
14	Foam Strip: 1" x 18" x 3/32"	0.5	1600-9002-001
16	Cap: Alum Elect 33000uf 63V	1	1500-9033-002
17	Clamp: Cable	2	2500-9080-002
18	Clamp: Clip Dek	2	6000-9020-004
19	Washer: Flat #8	AR	2800-9055-105
20	Screw: PH PHL 8-32 x .375"	AR	2800-9007-109
21	Cable Tie: 5.5"	1	6000-0051-001

## 7. Parts List Section

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**77-3023-001**

**FOS Cooling, Lower Shroud**

Ref Designator	Description	Qty	Part Number
1	Blower Inlet	1	77-0005-001
2	Blower Inlet Bottom	1	77-0028-001
3	Locite Super Bonder: 414	AR	1600-0050-001
4	Blower Assembly	1	77-3026-001
5	Nut Plate	1	77-0110-001
6	Screw: PH PHL 4-40 x .875"	AR	2800-9005-119
7	Washer: Split Lock #4	AR	2800-9057-105

**77-3024-001**

**Augmentation Valve Assembly**

1	Augmentation Valve With Connector	1	4500-9100-003
2	Vibration Control Pipe Strap 1"	1	2500-9095-001
3	Vibration Control Mount, Natural Rubber	2	2500-9096-001
4	Fitting: 1/4-28 x 1/8 Tube	2	2500-9022-007
5	Screw: PH PHL 6-32 x .375"	AR	2800-9006-109
6	Washer: Split Lock #6	AR	2800-9057-107
7	Screw: FH PHL 8-32 x .250"	AR	2800-9010-105
8	Augmentation Valve Clamp	1	77-0112-001
9	Augmentation Valve Bracket	1	77-0113-001

**77-3200-001**

**Pump Assembly**

1	Mounting Plate: Motor	1	90-0851-001
2	Mounting Plate: Bellows	1	90-0852-001
3	Side Plate Blank	2	90-0856-001
5	Nesting Plate: Spring	1	90-0862-001
6	Spacer: Ball Nut Mtg Plate	4	90-0863-001
7	Spacer: Ball Nut	1	90-0867-001
8	Ball Screw Nut: Mounting Plate	1	90-0868-001
9	Tie Bar: Blank	4	90-0869-001
11	Bracket: PCB Mtg Sensor	1	90-0880-001
12	Cover: Top Pump	2	96-0065-001
13	Insulation Pump End	1	90-0887-001
14	Assy: Ball Nut / Lead Screw	1	90-0899-501
15	Home Sensor PCB	1	90-1260-502
16	Cable: Pump Control / Home Sense	1	96-3730-001
17	Cable: Ground Strap 10"	1	96-3728-001
18	Bellows Assembly	1	90-3900-501
19	Flag: Opto	1	91-0867-001
20	Pneumatic Control System Assembly	1	96-3006-001
21	Insulation: Side Plate Blank	4	96-0078-001
22	Insulation: Pump End Motor	1	96-0079-001

---

## 7. Parts List Section

77-3200-001

### Pump Assembly (continued)

Ref Designator	Description	Qty	Part Number
24	Adhesive: Medium Strength	0	1600-0084-001
28	Spring: Compression, 4.5"	1	2500-9025-002
29	Gasket: Compression Spring	2	2500-9027-001
31	Screw: FH PHL 4-40 x 1/4"	0	2800-9012-105
32	Washer: Plain #10 Lg Pat.	0	2800-9055-119
33	Washer: Split Lock #10	0	2800-9057-112
34	Nut: Keps 4-40	0	2800-9073-001
36	Screw: Socket Hd 10-32 x 1/2"	0	2800-9161-413
37	Screw: Set 10-32 x 3/16"	0	2800-9231-182
38	Screw: FH Hex 10-32 x 5/8"	0	2800-9235-001
39	Screw: Hex 1/4-20 x 1"	0	2800-9244-001
40	Motor / Encoder	1	77-3021-001
41	Locite Super Bonder: 414	0	1600-0050-001
42	O-Ring: Static Seal	1	2500-9001-001
43	High Vacuum Grease	0	1600-0083-001
44	Screw: PH PHL 4-40 x .5"	0	2800-9005-113
45	Washer: Split Lock #4	0	2800-9057-105
46	Foam Strip: 1" x 18" x 3/32"	0.5	1600-9002-001
47	Fitting Elbow 10-32 x 1/8" Tube	1	2500-9017-031
48	Fitting, Adjustable 90 Deg Elbow 10-32	1	2500-9300-027

96-1040-001

### Flasheard Assembly

1	Flash Card Interface Blank	1	96-1042-001
4	Screw: PH PHL SS M2 x 10mm	2	2800-9295-003
5	Washer: Flat #2	2	2800-9055-102
6	Washer: Split Lock #2	2	2800-9057-103
7	Nut: Hex SS M2	2	2800-9296-002
J1	Header: 32 x 2	1	2100-9142-003
J2	Header: 68 Pin Str. w / right	1	2100-9142-014

96-3013-001

### Helium Transducer Assembly

1	Transducer: 0-3000 PSI	1	5500-9003-001
2	Connector: Plug 6 Pin	1	2100-9147-001
3	Terminal: Male 18-24 AWG	5	2100-9147-002
4	Tubing: Heat Shrink 3/16"	AR	3100-0008-001

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### CHAPTER 8: Schematic and Assembly Drawings 8-1

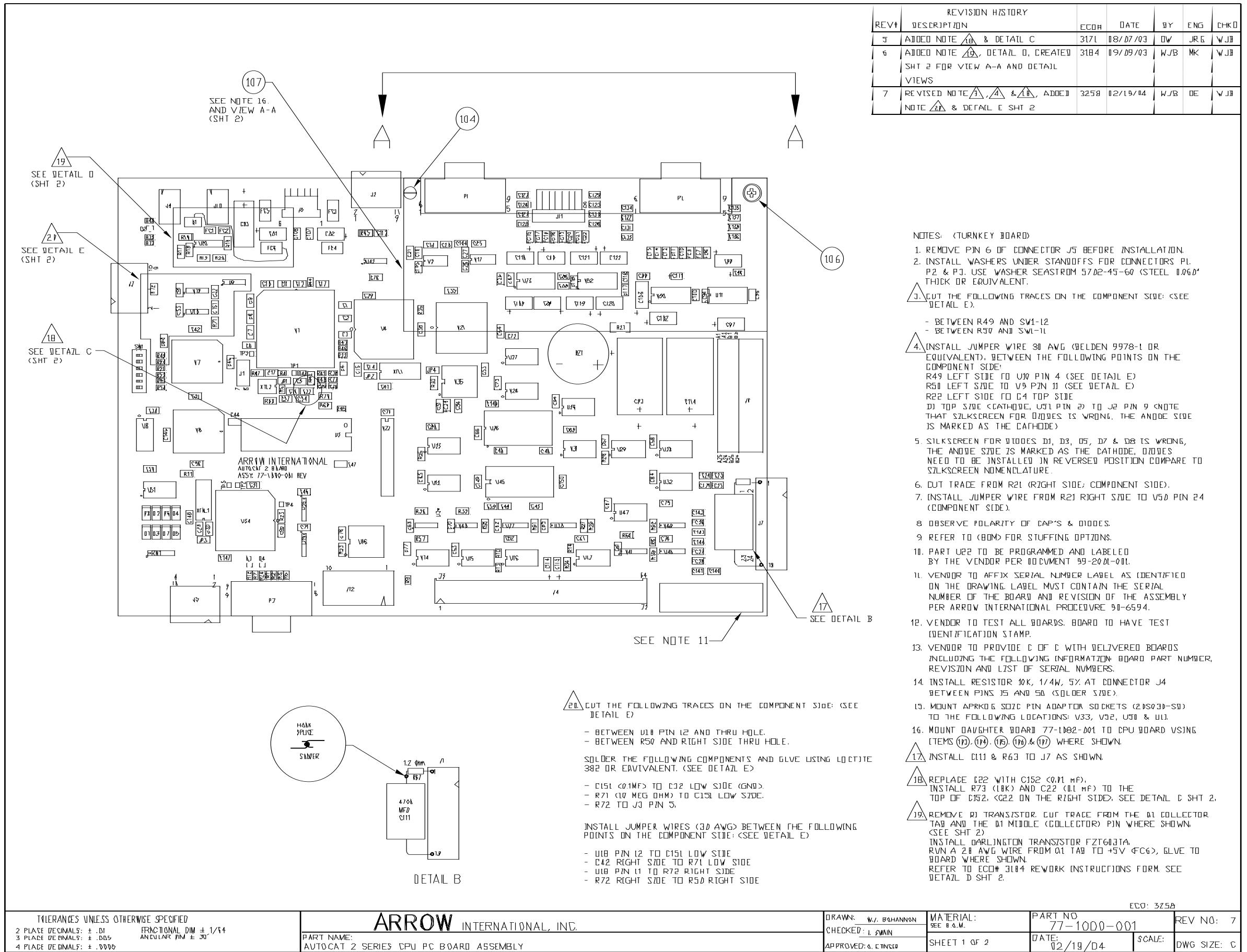
---

<b>8.1: Drawings Section . . . . .</b>	<b>8-3</b>
77-1000-001 CPU PCB Assembly Drawing .....	8-3
77-1004-001 CPU PCB Schematic Drawing .....	8-5
77-1010-001 Front End PCB Assembly Drawing .....	8-8
77-1014-001 Front End PCB Schematic Drawing .....	8-10
77-1100-001 I/O PCB Assembly Drawing .....	8-13
77-1104-001 I/O PCB Schematic Drawing .....	8-14
77-1110-001 5/12 Volt Alarm PCB Assembly Drawing .....	8-15
77-1114-001 5/12 Volt Alarm PCB Schematic Drawing .....	8-16
77-3000-001 AutoCAT™ Assembly Drawing .....	8-17
77-3001-001 FOS Connector Assembly Drawing .....	8-26
77-3007-001 Helium Tank Regulator Assembly Drawing .....	8-27
77-3008-001 Front Panel Assembly Drawing .....	8-28
77-3009-001 Left Side Panel Assembly Drawing .....	8-29
77-3012-001 Balloon Interface Block Assembly Drawing .....	8-30
77-3014-001 Raise and Lower Mechanism Assembly Drawing .....	8-31
77-3016-001 Display Module Assembly Drawing .....	8-34
77-3200-001 Pump Mechanism Assembly Drawing .....	8-35
96-3019-001 Rotation Latch Assembly Drawing .....	8-36

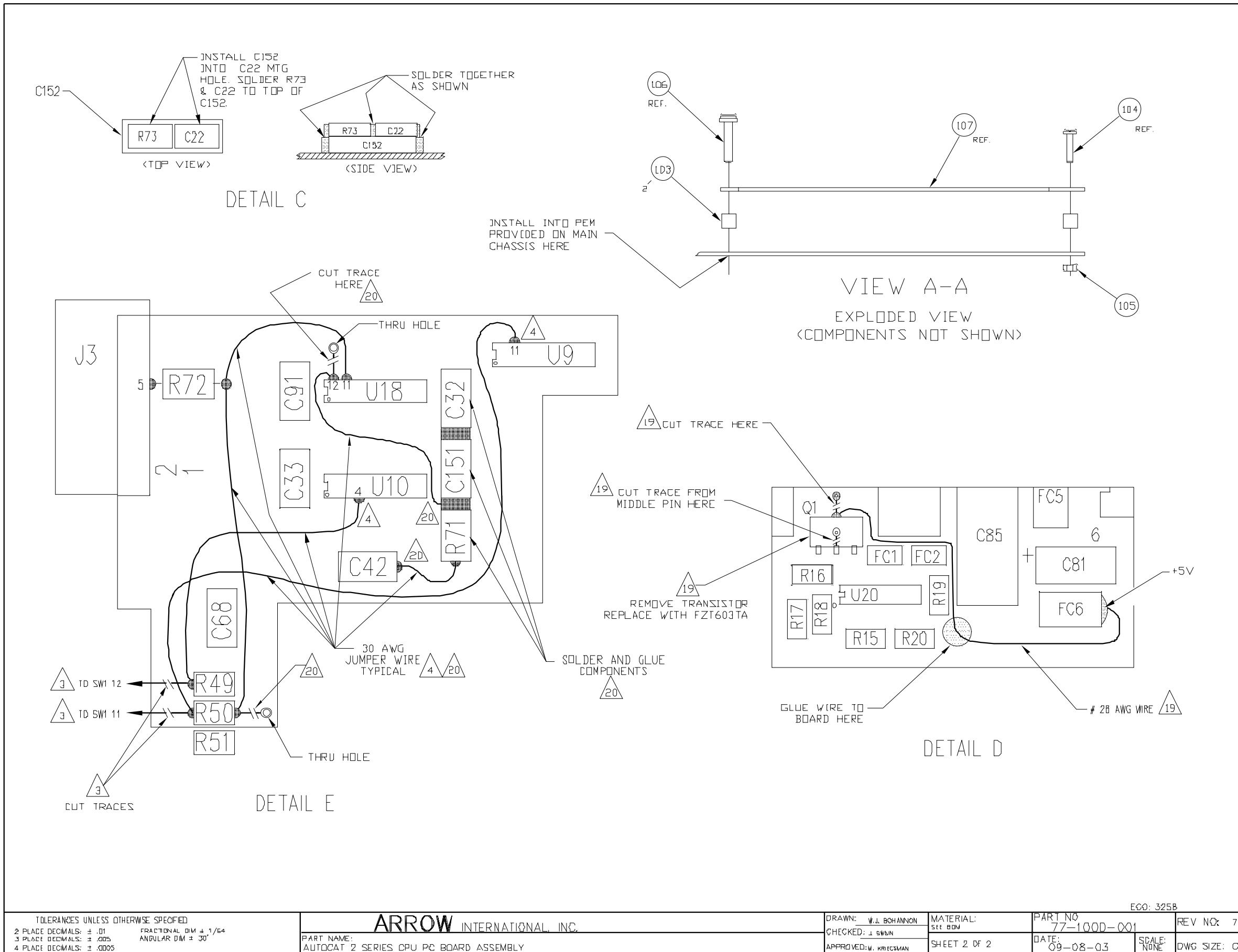
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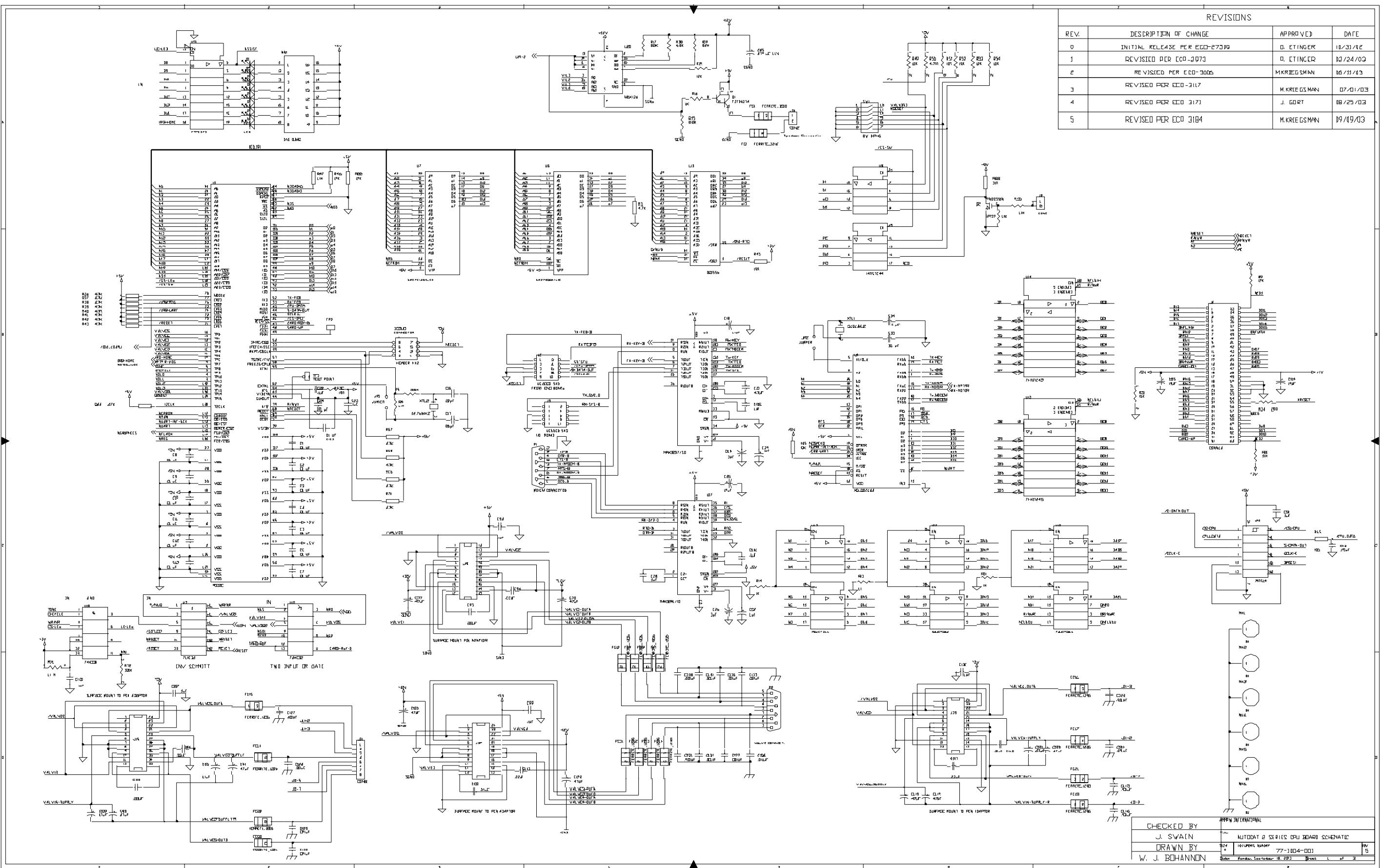
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77-1000-001 (1 of 2)**



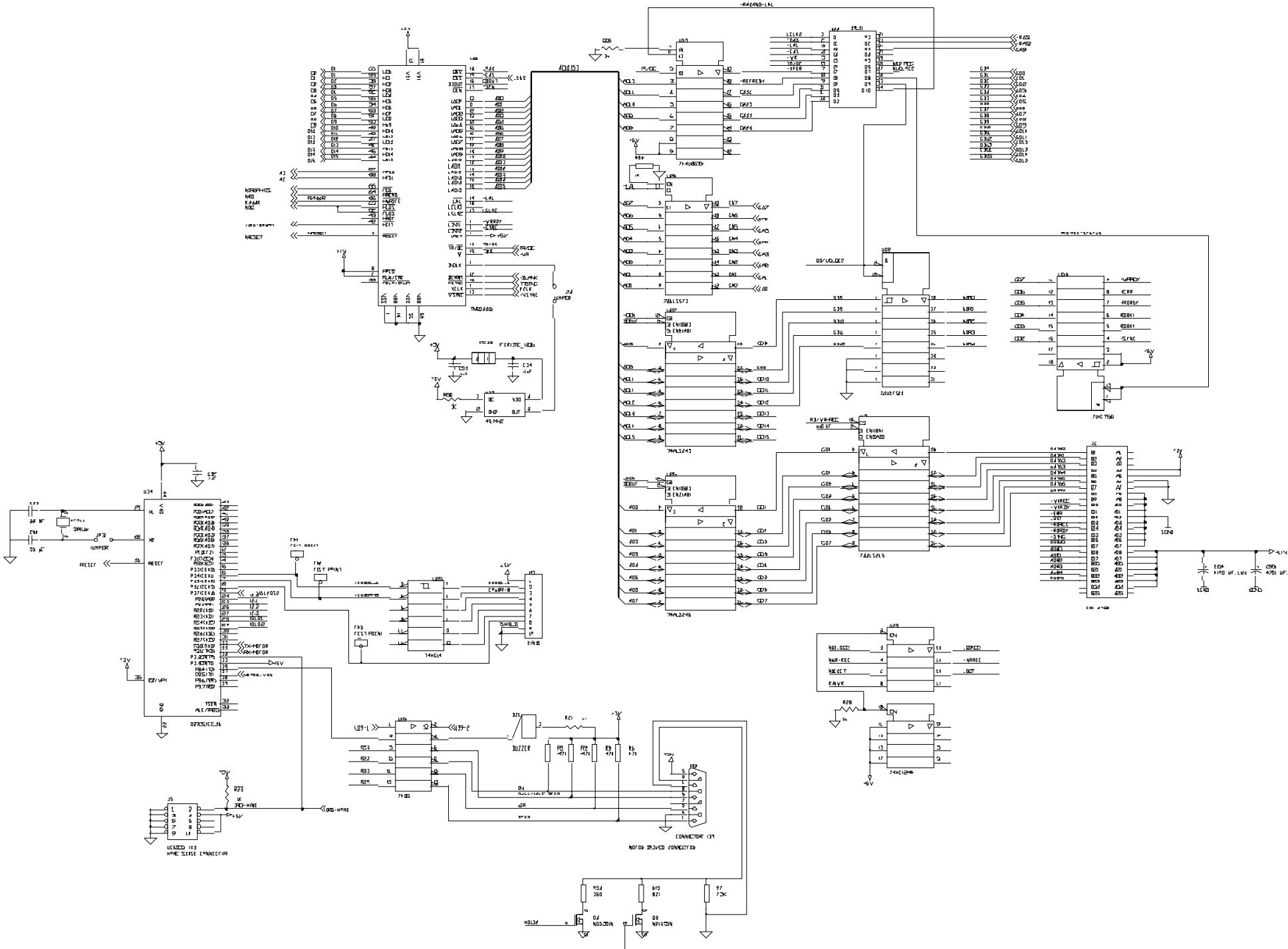
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77-1000-001 (2 of 2)**



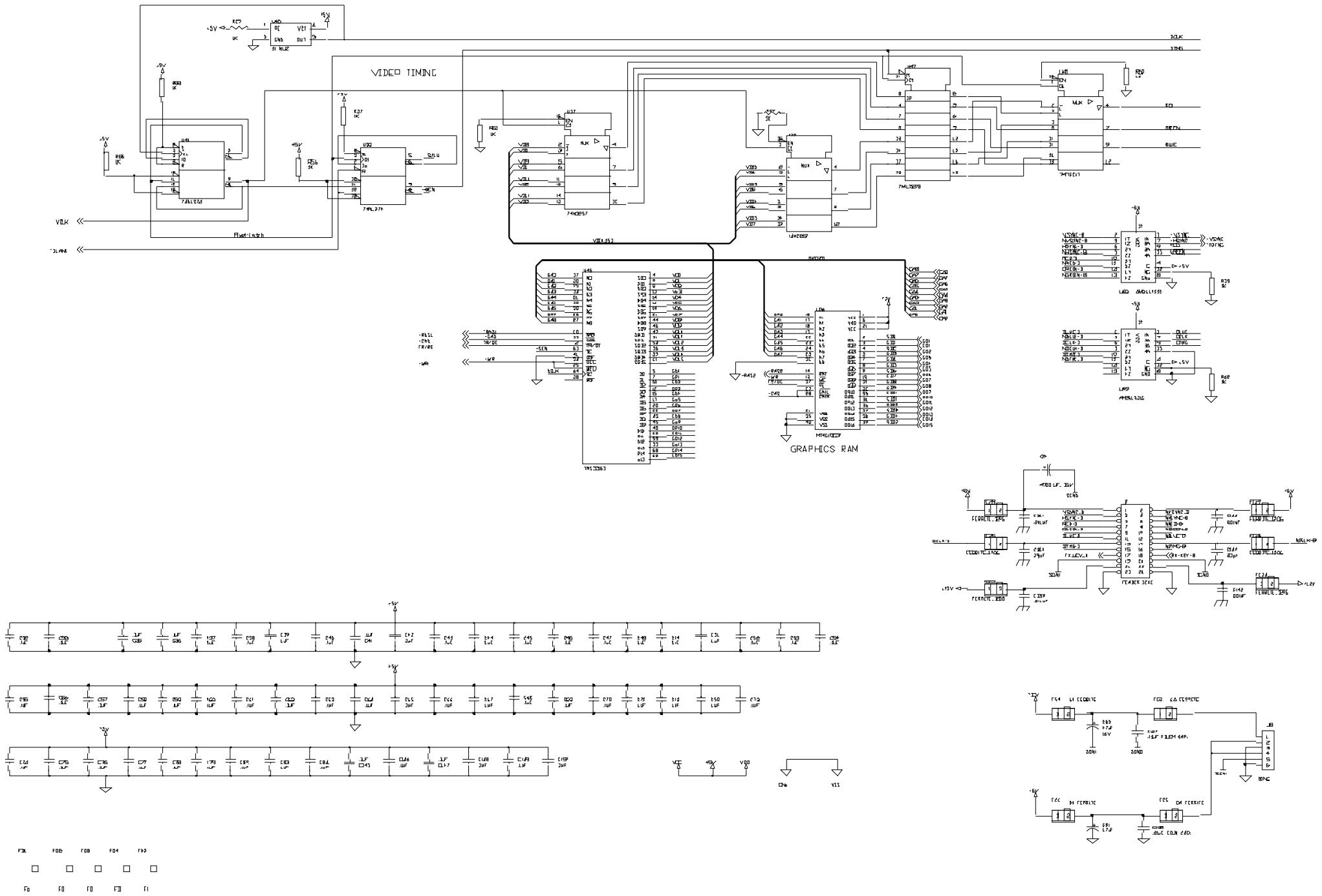
**Open flap to view schematic drawing  
77-1004-001 (1 of 3)**



**Open flap to view schematic drawing  
77-1004-001 (2 of 3)**



**Open flap to view schematic drawing  
77-1004-001 (3 of 3)**

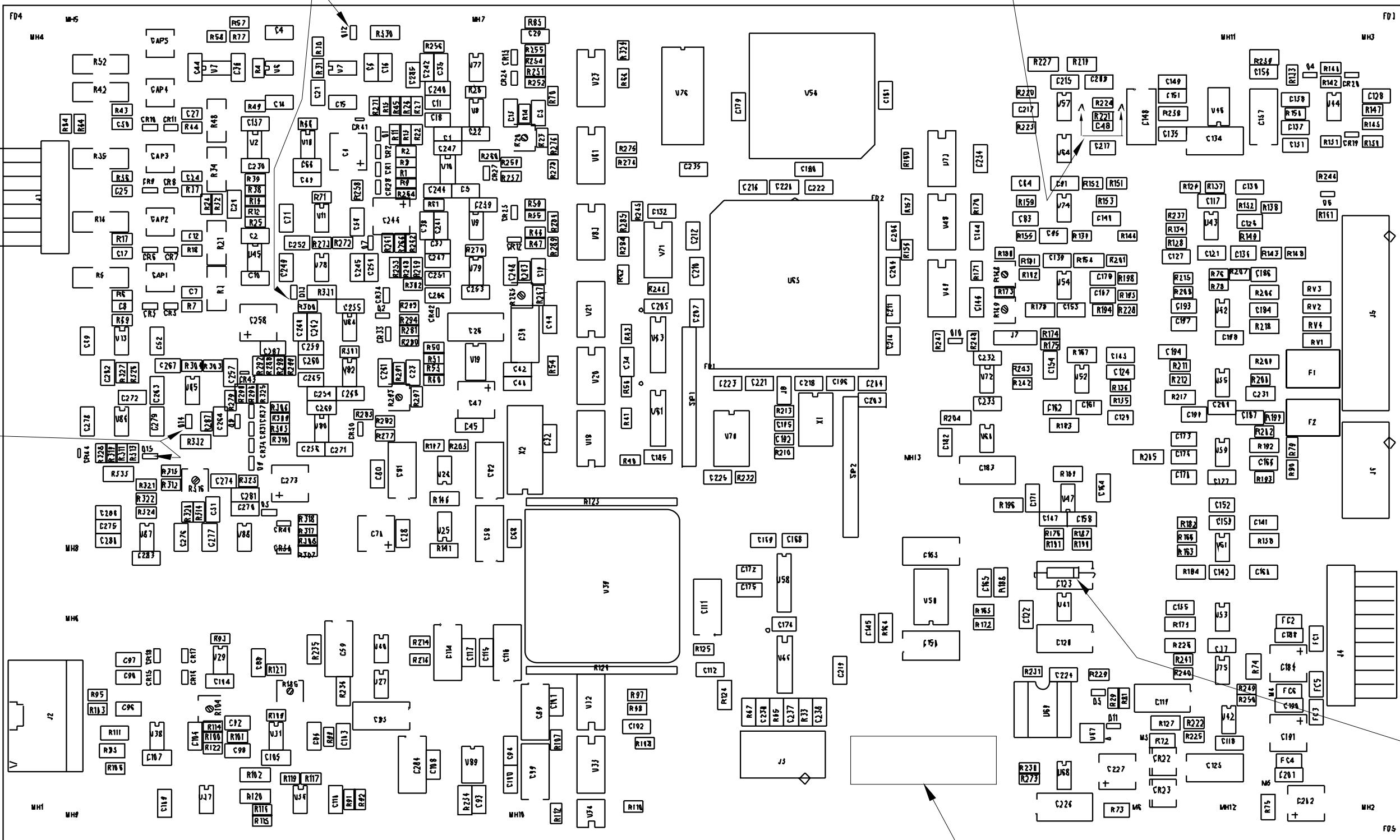


NEW INTERNATIONAL	
REV.	AUTOCOM 2 SERIES CPU BOARD SCHEMATIC
ISN	DOCUMENT NUMBER 77-1004-D01
120	PRINTED BY SOUTHERN CO. INC. 1982

**Open flap to view schematic drawing  
77-1010-001 (1 of 2)**

SEE NOTE 10

ADD C48 IMFD ACROSS R221 (SEE SECTION A-A SHT 2)



SEE SHEET 2 FOR NOTES

**ASSEMBLY (TOP SIDE)**

ECO: 3260

TOLERANCES UNLESS OTHERWISE SPECIFIED  
2 PLACE DECIMALS:  $\pm .01$  FRACTIONAL DIM  $\pm 1/64$   
3 PLACE DECIMALS:  $\pm .005$  ANGULAR DIM  $\pm 30'$   
4 PLACE DECIMALS:  $\pm .0005$

**ARROW** INTERNATIONAL, INC.

PART NAME:  
AUTOCAT 2 SERIES FRONT END BOARD ASSEMBLY

DRAWN: W.J.B.DHANNON  
CHECKED: J.SWAIN  
APPROVED: D.ZHANG

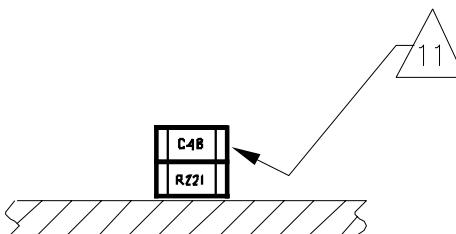
MATERIAL:  
SEE NOTES  
SHEET 1 OF 2

PART NO:  
77-1010-001  
DATE:  
10/27/03

REV NO: 4  
SCALE:  
DWG SIZE: B

**Open flap to view schematic drawing  
77-1010-001 (2 of 2)**

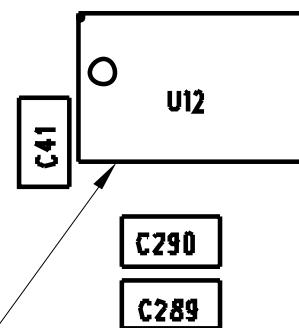
REVISION HISTORY						
REV#	DESCRIPTION	ECO#	DATE	BY	ENG	CHKD
3	C11,C247,C260 & C275 (47pf) C1206CG4 70J9B200 WAS (1nF) C1206C102JIGACTU	3211	10/27/03	DW	MK	DZ
4	ADDED DIODE CR45 ACROSS C123 AND NOTE △12 & △13	3260	12/17/03	DW	OE	JCS



SECTION A-A  
(NTS)



G1501



SEE NOTE 9

THIS IS A TURNKEY PC BOARD

NOTES:

1. OBSERVE POLARITY OF CAPS AND DIODES.
2. REFER TO (BOM) FOR STUFFING OPTIONS.
3. PARTS U12 AND U69 ARE PROGRAMMED BY THE VENDOR.
4. IF ALTERNATE PART PIC16C715-20/SO IS USED FOR U12, THEN PROGRAMMER NEEDS TO BE SET TO PIC16C715.
5. CONNECT J7 PINS 1 AND 2 USING JUMPER JP9. CONNECT J8 PINS 1 AND 2 USING JUMPER JP8.
6. VENDOR TO AFFIX SERIAL NUMBER LABEL AS IDENTIFIED ON THE DRAWING. LABEL WILL CONTAIN SERIAL NUMBER OF THE BOARD AND REVISION OF THE ASSEMBLY AS PER ARROW INTERNATIONAL PROCEDURE 90-6594.
7. VENDOR TO TEST ALL BOARDS. BOARDS TO HAVE TEST IDENTIFICATION STAMP.
8. VENDOR TO PROVIDE C OF C WITH DELIVERED BOARDS WITH INFORMATION ON BOARD PART NUMBER, REVISION AND LIST OF SERIAL NUMBERS.
9. U12 IS NOT USED, DO NOT INSTALL.
10. Q12, Q13, Q14 & Q15 ARE NOT USED, DO NOT INSTALL.
11. ADD CAPACITOR C48 ACROSS R221.
12. INSTALL DIODE CR45 ACROSS C123.
13. C236, C237, C238 ARE NOT USED. DO NOT INSTALL.

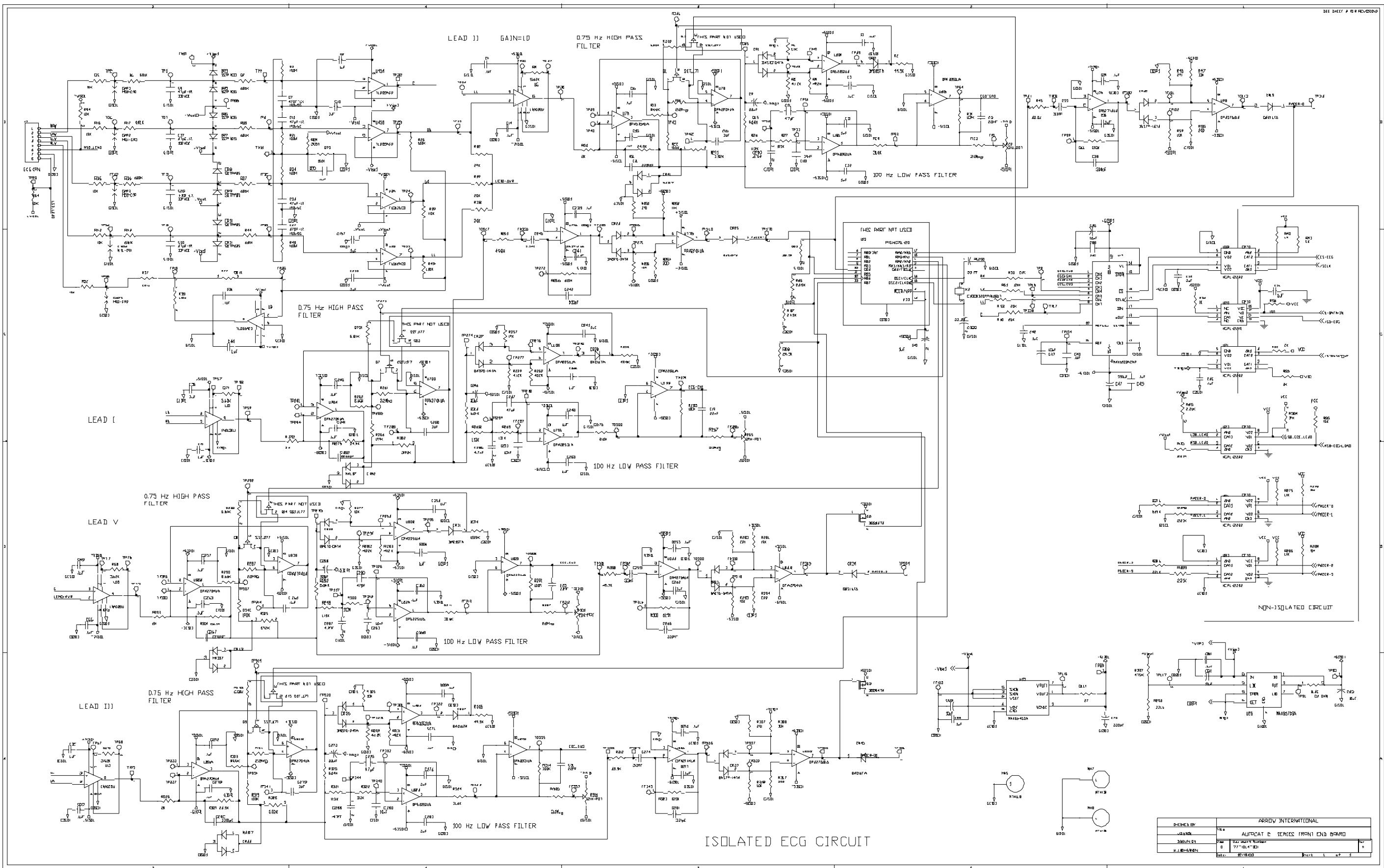
G1502

ASSEMBLY (BOTTOM SIDE)

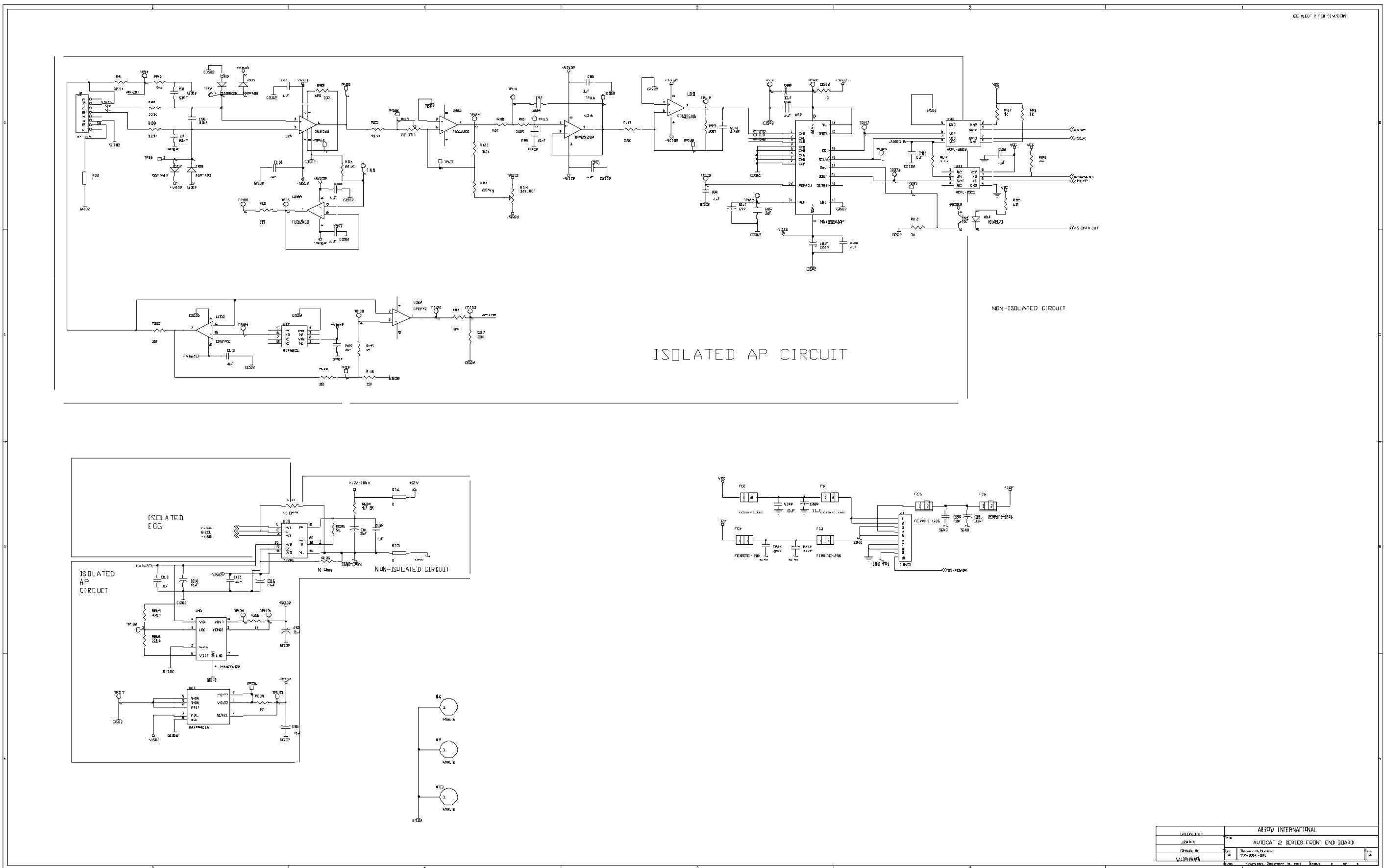
ECO: 3260

TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: ± .01 3 PLACE DECIMALS: ± .005 4 PLACE DECIMALS: ± .0005	FRACTIONAL DIM ± 1/64 ANGULAR DIM ± 30'	ARROW INTERNATIONAL, INC. PART NAME: AUTOCAT 2 SERIES FRONT END BOARD ASSEMBLY	DRAWN: W.J.BOHANNON CHECKED: J.SWAIN APPROVED: D. ETINGER	MATERIAL: SEE B.O.M. SHEET 2 OF 2	PART NO: 77-1010-001 DATE: 12/17/03	REV NO: 4 SCALE: DWG SIZE: B
---	--	--	---	--------------------------------------	--	---------------------------------

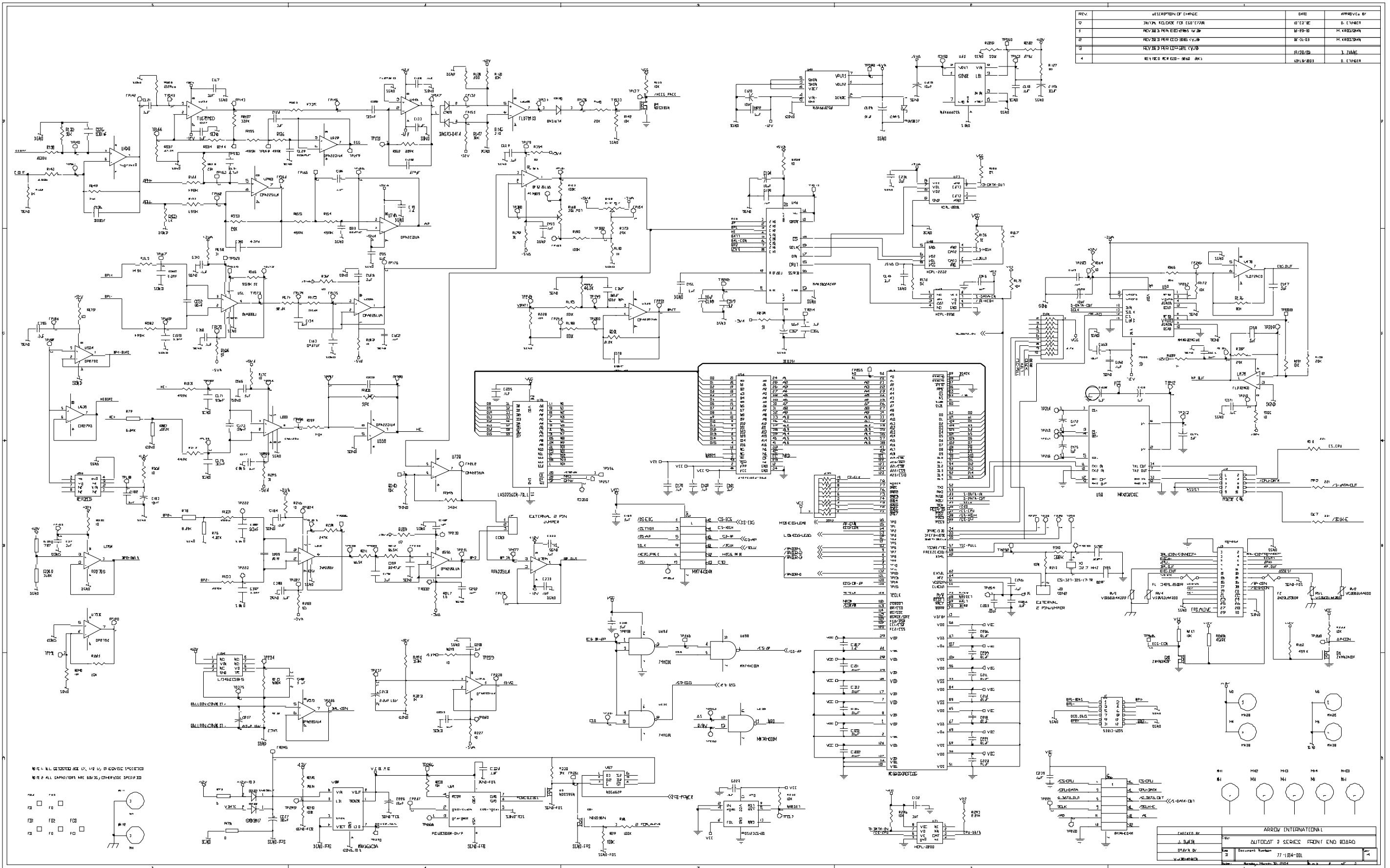
**Open flap to view schematic drawing  
77-1014-001 (1 of 3)**



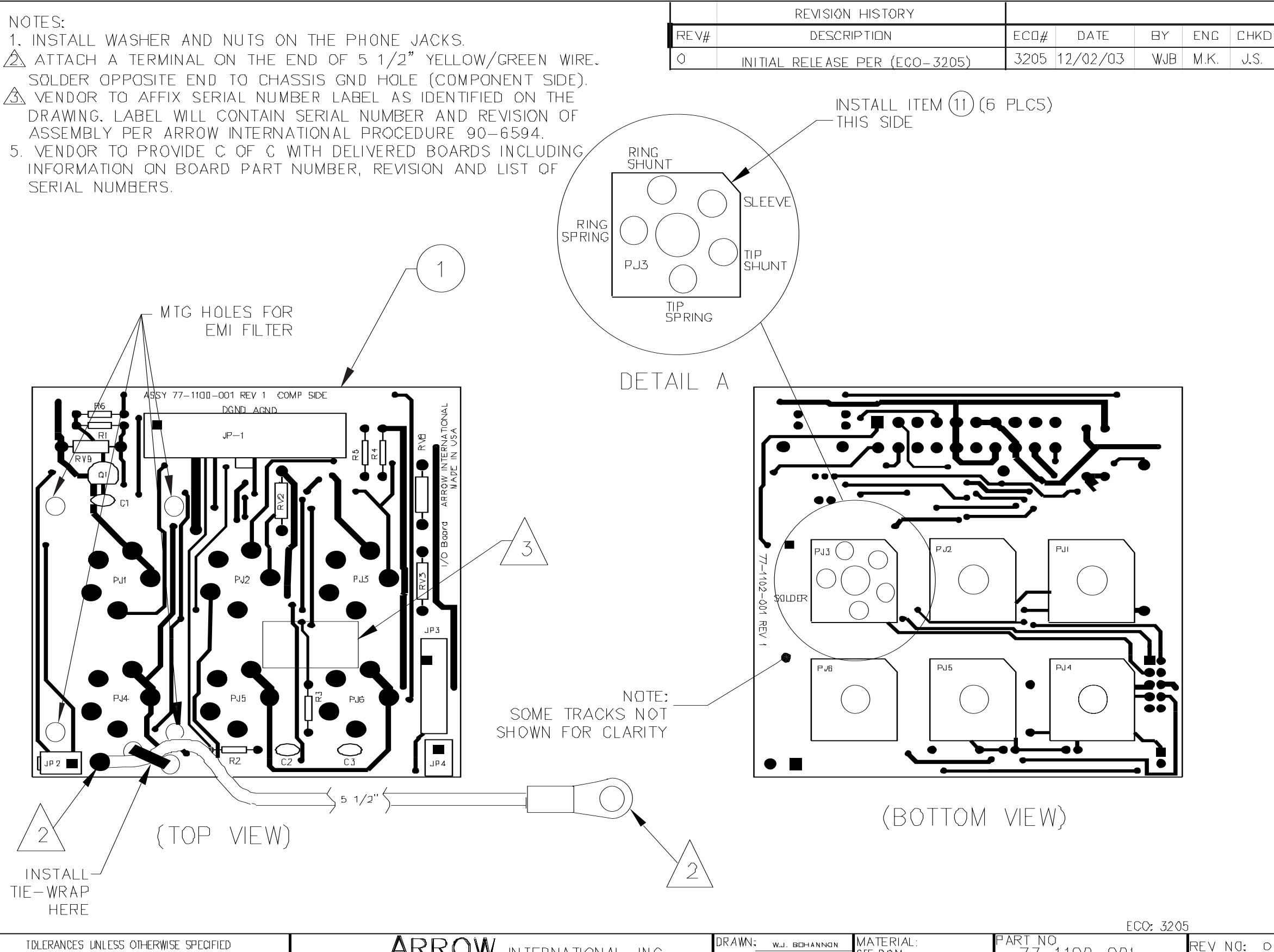
**Open flap to view schematic drawing  
77-1014-001 (2 of 3)**



**Open flap to view schematic drawing  
77-1014-001 (3 of 3)**



**Open flap to view assembly drawing 77-1100-001**



TOLERANCES UNLESS OTHERWISE SPECIFIED  
 2 PLACE DECIMALS: ± .01 FRACTIONAL DIM ± 1/64  
 3 PLACE DECIMALS: ± .005 ANGULAR DIM ± 30°  
 4 PLACE DECIMALS: ± .0005

**ARROW** INTERNATIONAL, INC.

PART NAME:  
I/O PCB AUTOCAT 2 SERIES

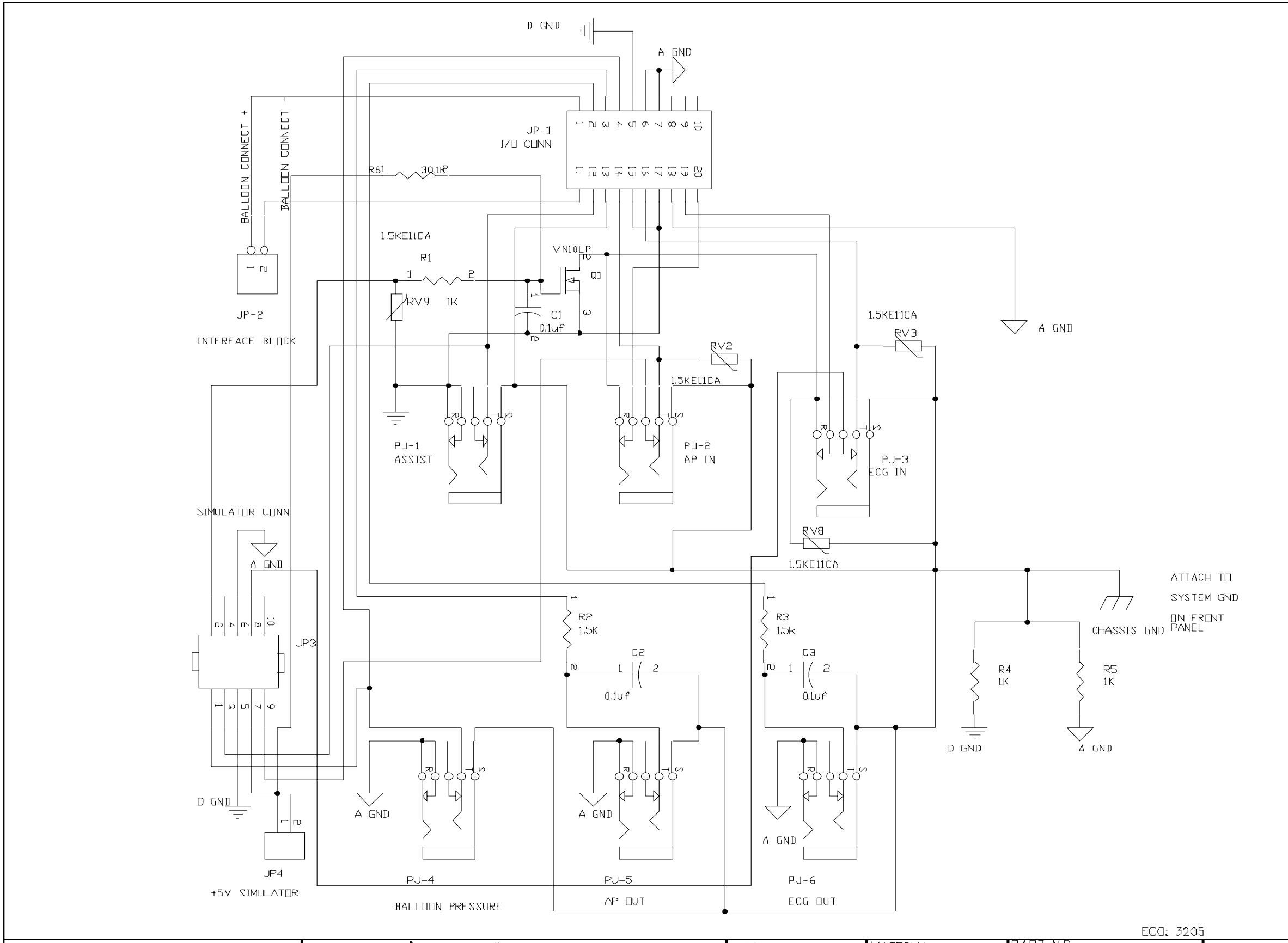
DRAWN: W.J. BOHANNON  
 CHECKED: J. SWAN  
 APPROVED: M. KRIEGSMAN

MATERIAL:  
SEE B.O.N.  
 SHEET SHEET: 1 OF 1

PART NO: 77-1100-001  
 REV NO: 0  
 DATE: 09-05-03  
 SCALE: DWG SIZE: A

ECO: 3205

**Open flap to view assembly drawing 77-1104-001**



TOLERANCES UNLESS OTHERWISE SPECIFIED  
 2 PLACE DECIMALS: ± .01 FRACTIONAL DIM ± 1/64  
 3 PLACE DECIMALS: ± .005 ANGULAR DIM ± 30°  
 4 PLACE DECIMALS: ± .0005

**ARROW** INTERNATIONAL, INC.

PART NAME:  
 I/O PCB SCHEMATIC AUTOCAD 2 SERIES

DRAWN: W.J.BOHANNON  
 CHECKED: J.SWAIN  
 APPROVED: M.KREIGSMAN

MATERIAL: N/A  
 SHEET 1 OF 1

PART NO: 77-1104-001  
 REV NO: 0  
 DATE: 12/02/03  
 SCALE: DWG SIZE: A

**Open flap to view assembly drawing 77-1110-001**

REVISION HISTORY					
REV#	DESCRIPTION	ECO#	DATE	BY	ENG
1	D2 CLARIFICATION (REVISED VIEW A-A). B.O.M. CORRECTION ITEM 4 QTY 3 WAS 2	3265	12/30/03	WJB	MK
					JCS

77-1110-001 REV \_\_\_\_ MADE IN USA

ARROW INTL

COMP SIDE

F1

J1

J2

R1

R2

R3

R4

D1

D2

D3

D4

5V,12V ALARM

NC CUT THIS PIN OFF

VIEW A-A

A

INSTALL WITH ORIENTATION AS SHOWN  
(SEE VIEW A-A)

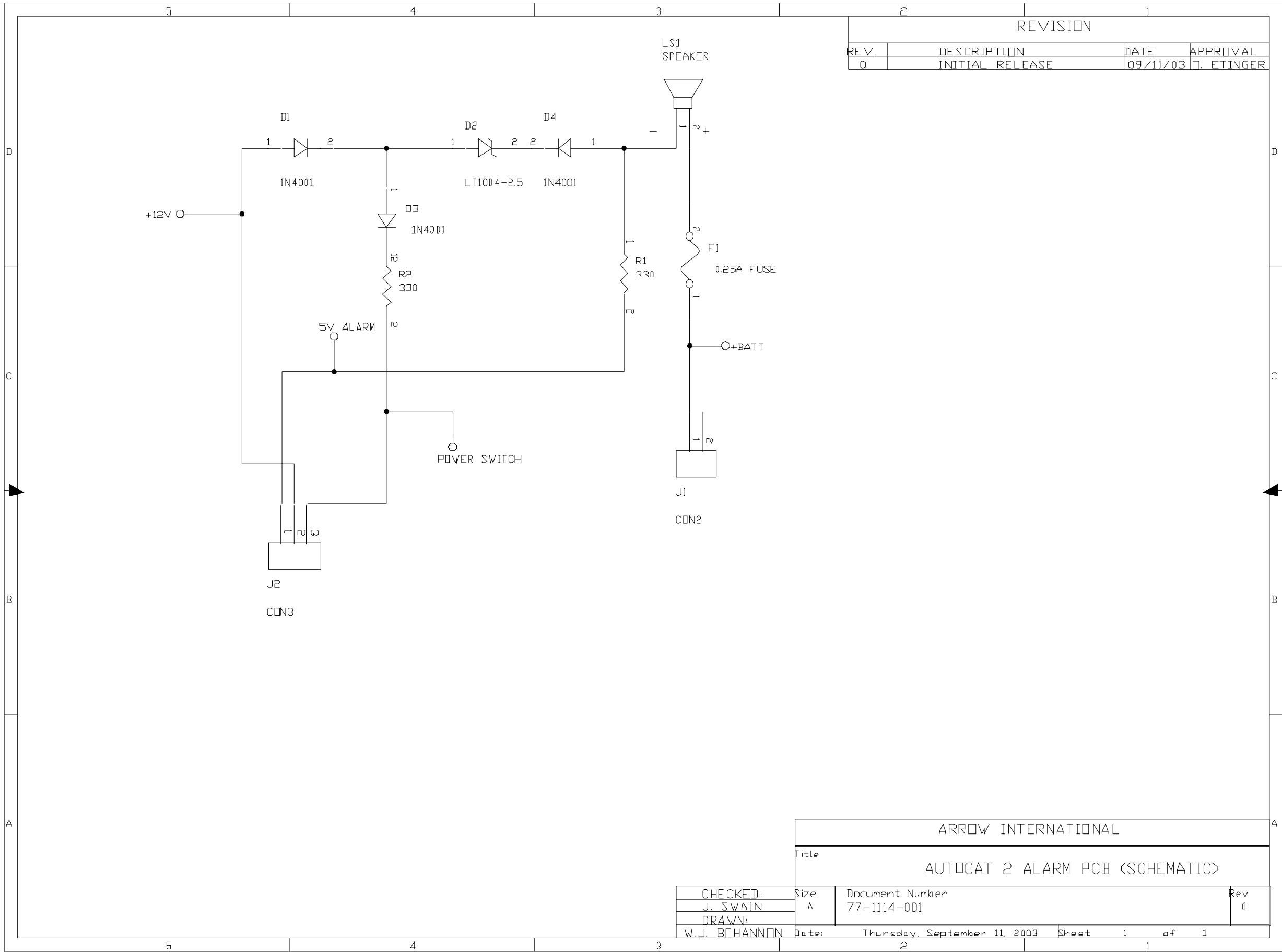
NOTE:

1. TURNKEY.

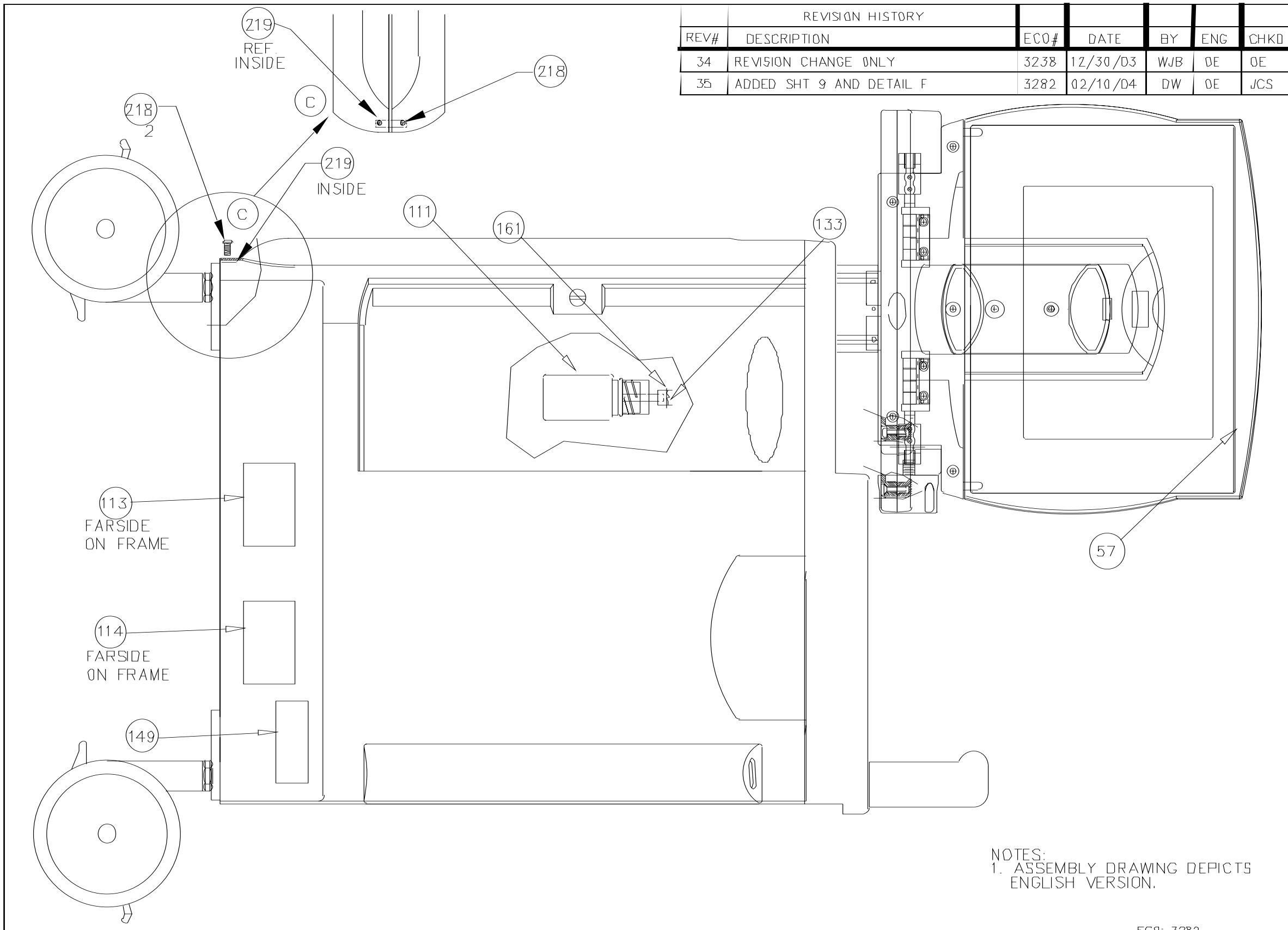
  

TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: $\pm .01$ FRACTIONAL DIM $\pm 1/64$ 3 PLACE DECIMALS: $\pm .005$ ANGULAR DIM $\pm 30'$ 4 PLACE DECIMALS: $\pm .0005$		ARROW INTERNATIONAL, INC.		DRAWN: W.J. BOHANNON CHECKED: P. PETERSON APPROVED: M. KRIEGLSMAN	MATERIAL: SEE B.O.M. SHEET SHEET: 1 OF 1	PART NO: 77-1110-001 DATE: 12-30-03	REV NO: 1 SCALE: 2/1 DWG SIZE: A
							ECO: 3265

**Open flap to view assembly drawing 77-1114-001**

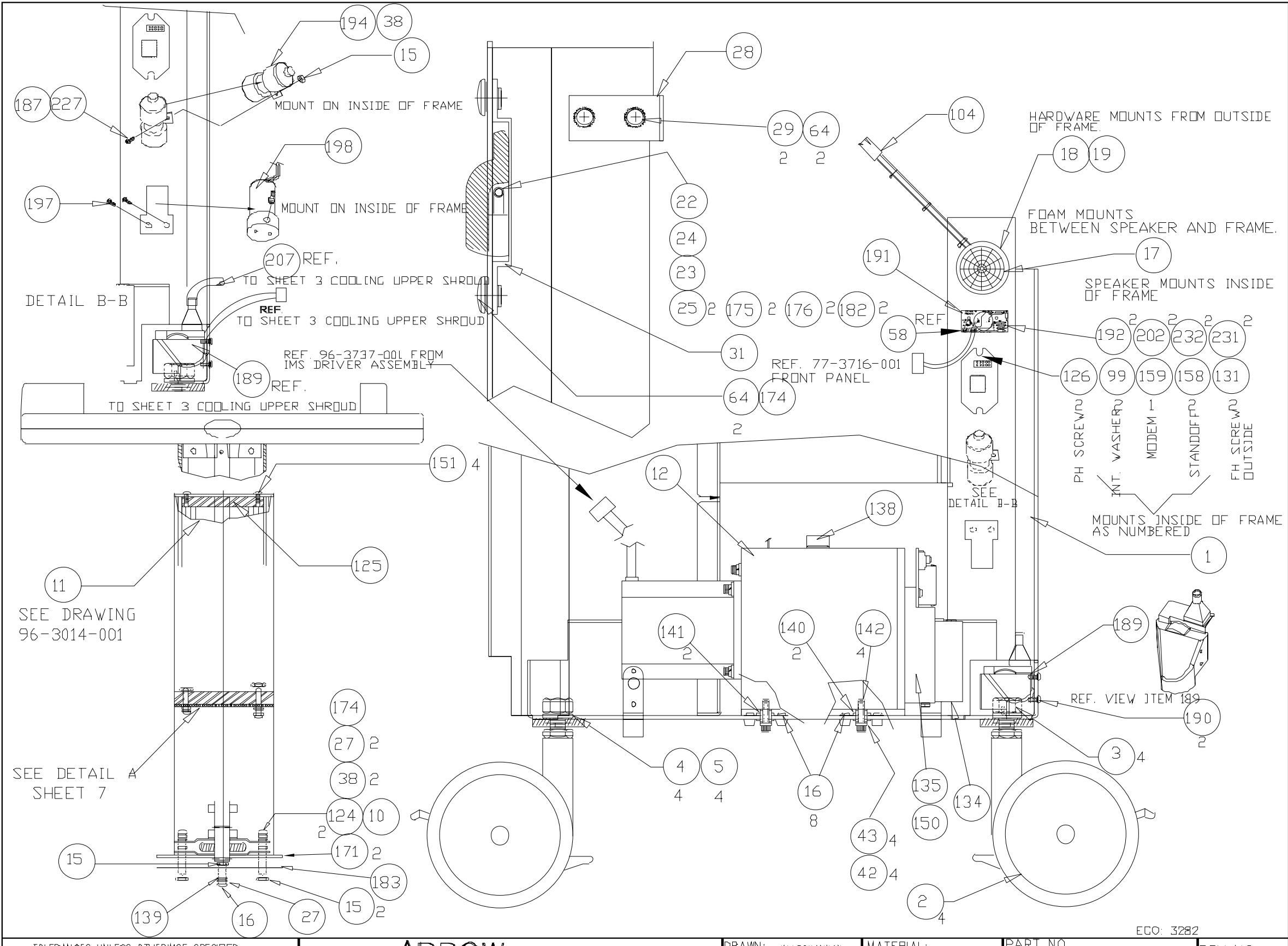


**Open flap to view schematic drawing  
77-3000-001 (1 of 9)**

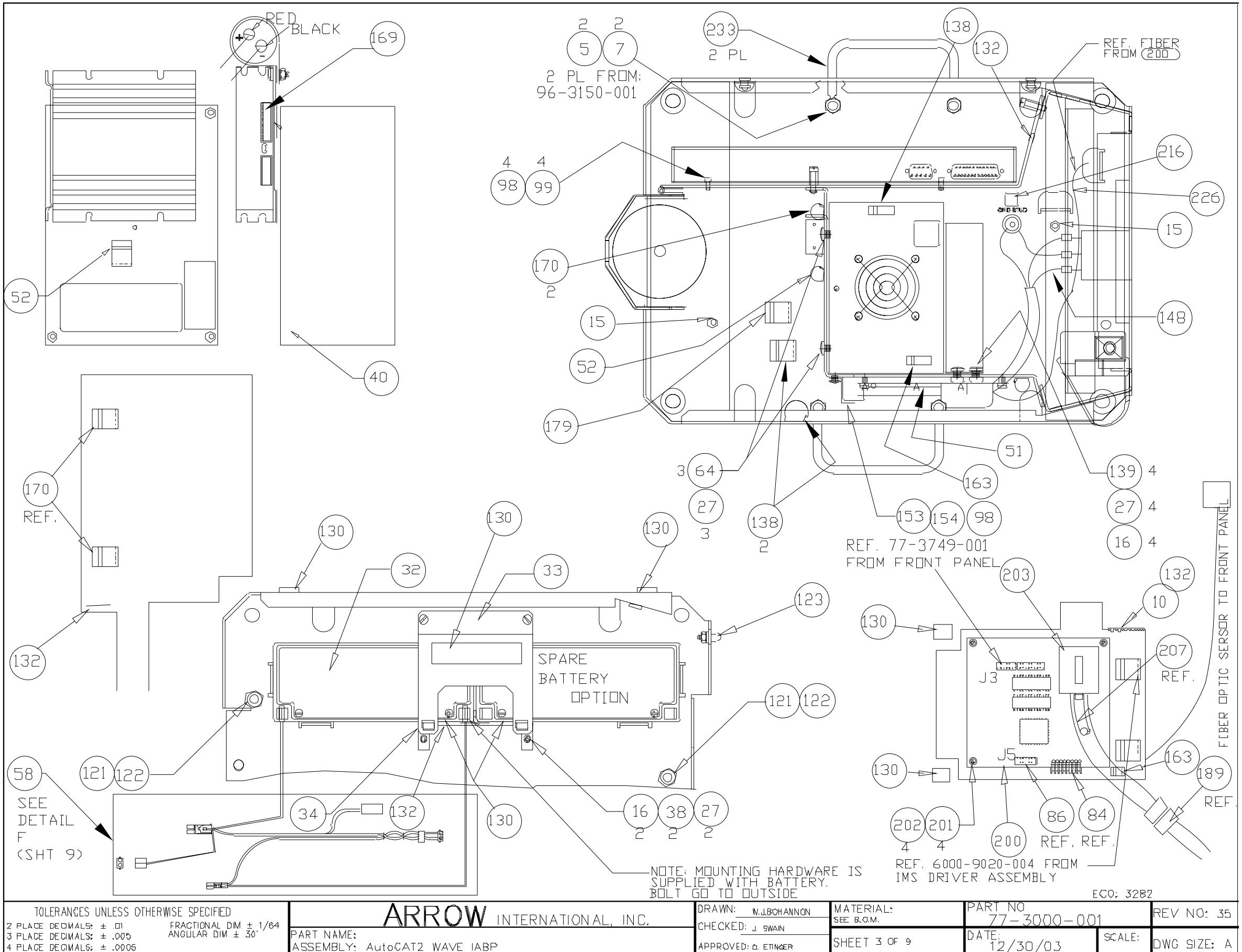


TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: ± .01      FRACTIONAL DIM ± 1/64 3 PLACE DECIMALS: ± .005      ANGULAR DIM ± 30° 4 PLACE DECIMALS: ± .0005	ARROW INTERNATIONAL, INC. PART NAME: ASSEMBLY: AutoCAT2 WAVE IABP	DRAWN: W.J. Bohannon CHECKED: J. SWAIN APPROVED: D. ETINGER	MATERIAL: SEE B.O.M. SHEET 1 OF 9	PART NO: 77-3000-001 DATE: 02/06/04	REV NO: 35 SCALE: DWG SIZE: A
---	---	---	--------------------------------------	--	----------------------------------

**Open flap to view schematic drawing  
77-3000-001 (2 of 9)**



**Open flap to view schematic drawing  
77-3000-001 (3 of 9)**



TOLERANCES UNLESS OTHERWISE SPECIFIED  
2 PLACE DECIMALS:  $\pm .01$  FRACTIONAL DIM  $\pm 1/64$   
3 PLACE DECIMALS:  $\pm .005$  ANGULAR DIM  $\pm 30^\circ$   
4 PLACE DECIMALS:  $\pm .0005$

ARROW INTERNATIONAL, INC.

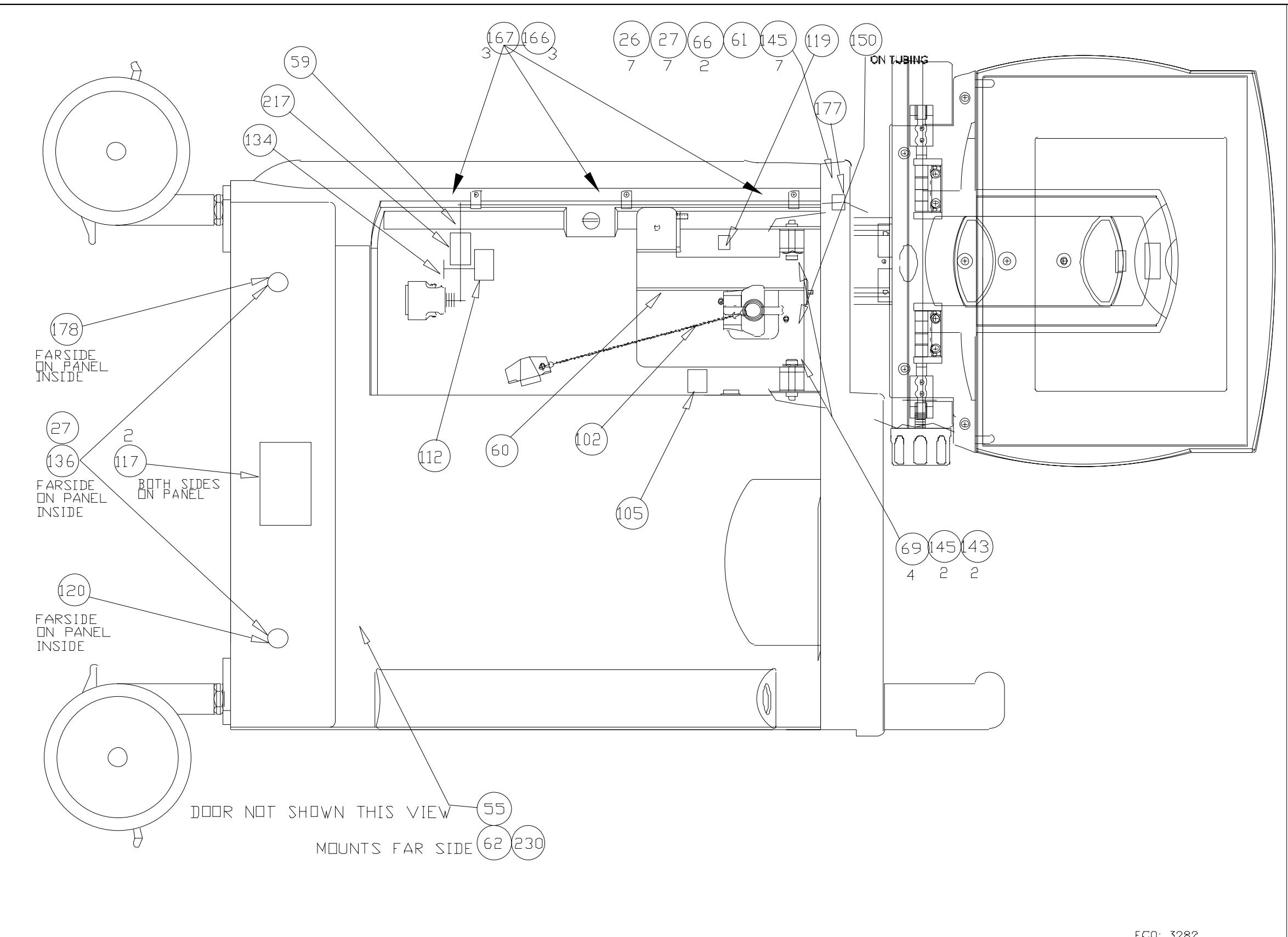
PART NAME:  
ASSEMBLY: AutoCAT2 WAVE IABP

DRAWN: W.J.BOHANNON  
CHECKED: J. SWAIN  
APPROVED: D. ETINGER

MATERIAL:  
SEE B.O.M.  
SHEET 3 OF 9

PART NO: 77-3000-001  
REV NO: 35  
DATE: 12/30/03  
SCALE: DWG SIZE: A

**Open flap to view schematic drawing  
77-3000-001 (4 of 9)**



TOLERANCES UNLESS OTHERWISE SPECIFIED  
2 PLACE DECIMALS:  $\pm .01$  FRACTIONAL DIM  $\pm 1/64$   
3 PLACE DECIMALS:  $\pm .005$  ANGULAR DIM  $\pm 30'$   
4 PLACE DECIMALS:  $\pm .0005$

ARROW INTERNATIONAL, INC.

PART NAME:  
ASSEMBLY: AutoCAT2 WAVE TABP

DRAWN: W.J.BOHANNON  
CHECKED: J.SAIN  
APPROVED: D. ETINGER

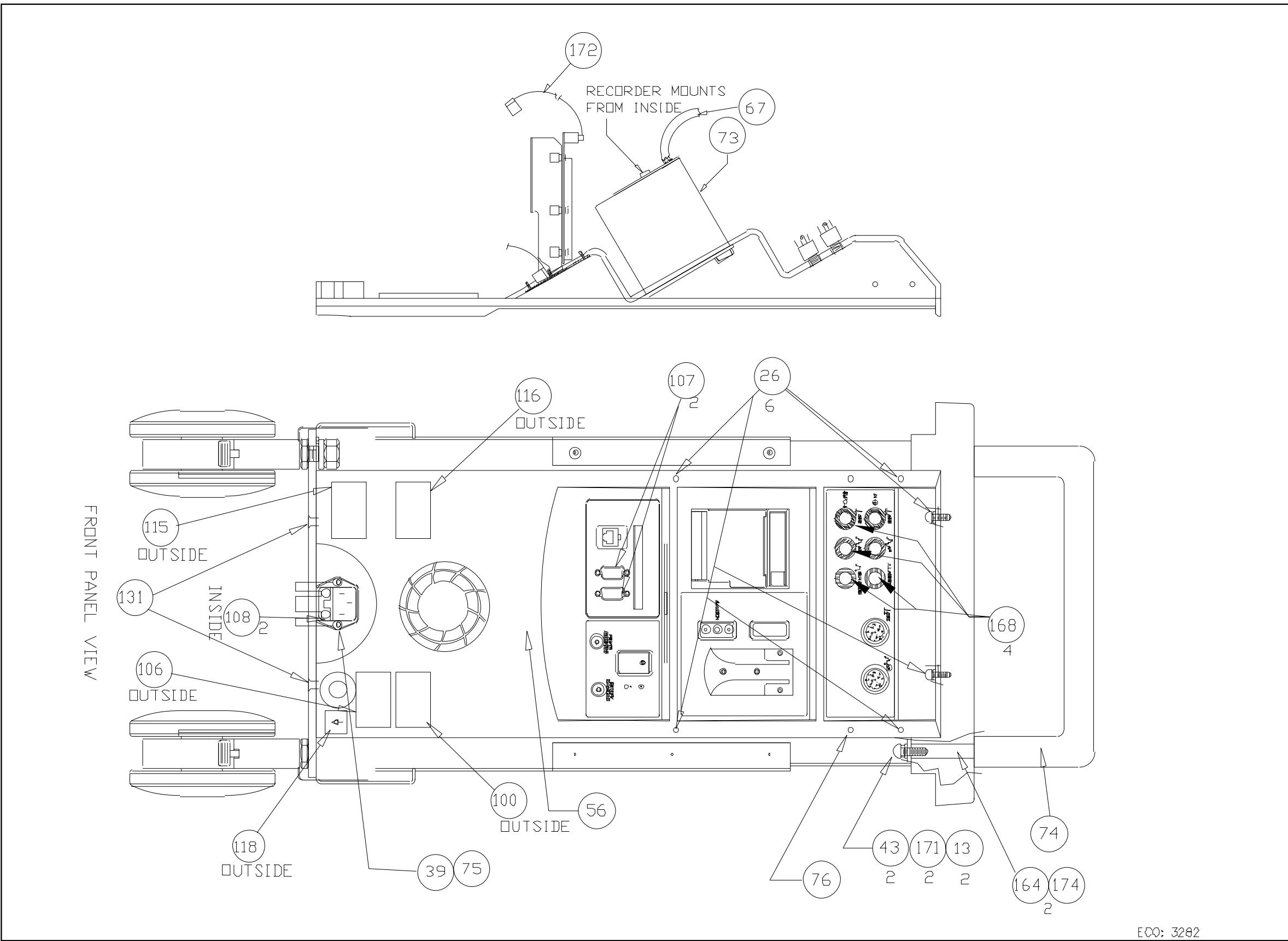
MATERIAL:  
SEE B.O.M.  
SHEET 4 OF 9

PART NO  
77-3000-001  
DATE  
12/30/03

REV NO: 35  
SCALE:  
DWG SIZE: A

ECO: 3282

**Open flap to view schematic drawing  
77-3000-001 (5 of 9)**



ECO: 3282

TOLERANCES UNLESS OTHERWISE SPECIFIED  
 2 PLACE DECIMALS:  $\pm .01$  FRACTIONAL DIM  $\pm 1/64$   
 3 PLACE DECIMALS:  $\pm .006$  ANGULAR DIM  $\pm 30'$   
 4 PLACE DECIMALS:  $\pm .0005$

**ARROW** INTERNATIONAL, INC.

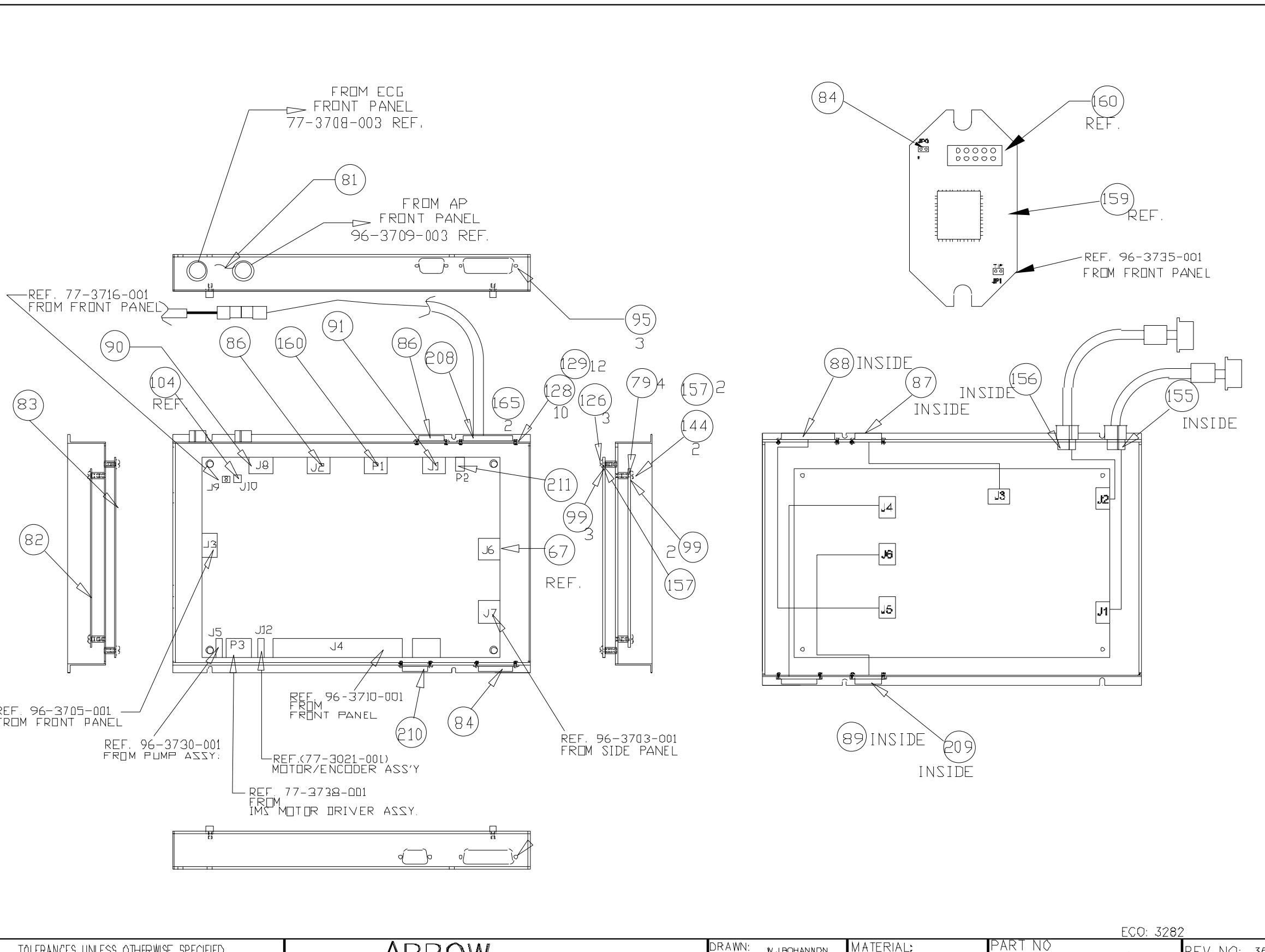
PART NAME:  
ASSEMBLY: AutoCAT2 WAVE IABP

DRAWN: W.J.BOHANNON  
CHECKED: J. SWAIN  
APPROVED: D. ETINGER

MATERIAL: SEE B.Q.M.  
SHEET 5 OF 9

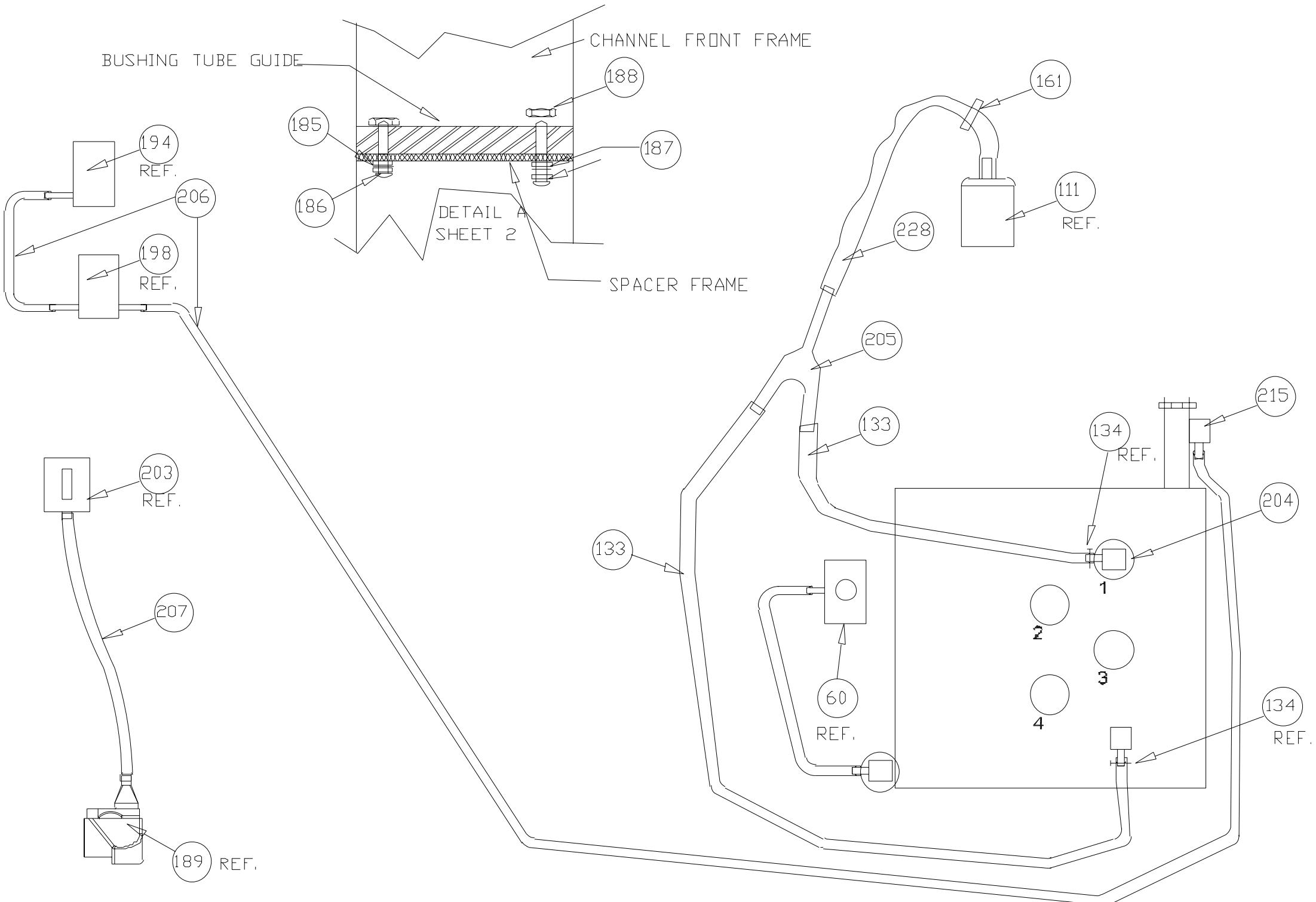
PART NO: 77-3000-001  
REV NO: 35  
DATE: 12/30/03  
SCALE: DWG SIZE: A

**Open flap to view schematic drawing  
77-3000-001 (6 of 9)**



TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: ± .01      FRACTIONAL DIM ± 1/64 3 PLACE DECIMALS: ± .005      ANGULAR DIM ± 3D° 4 PLACE DECIMALS: ± .0005	<b>ARROW</b> INTERNATIONAL, INC.	DRAWN: W.J.BOHANNON CHECKED: J. SWAIN APPROVED: D. ETINGER	MATERIAL: SEE B.O.M. PART NO: 77-3000-001 SHEET 6 OF 9	REV NO: 35 DATE: 12/30/03 SCALE:
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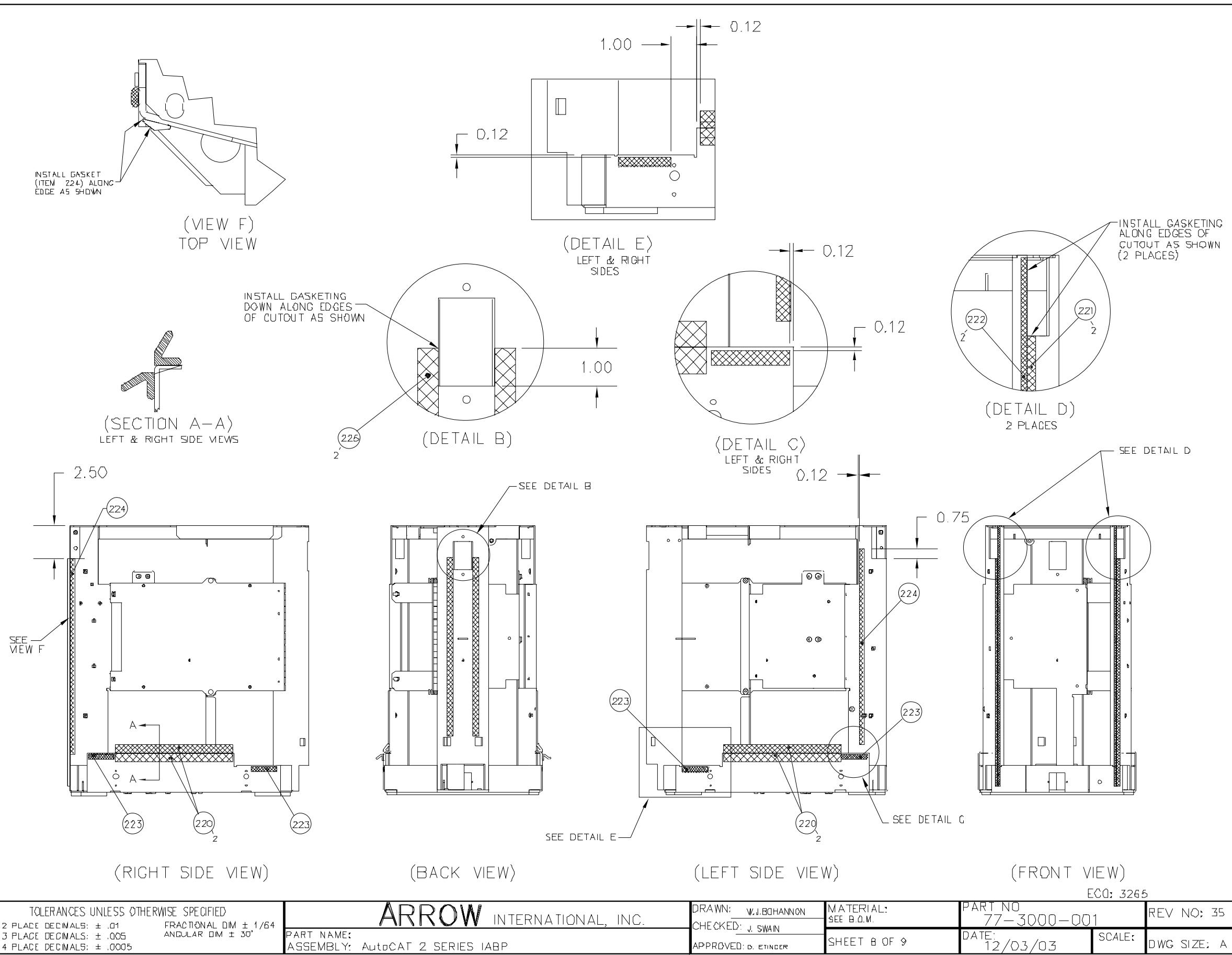
**Open flap to view schematic drawing  
77-3000-001 (7 of 9)**



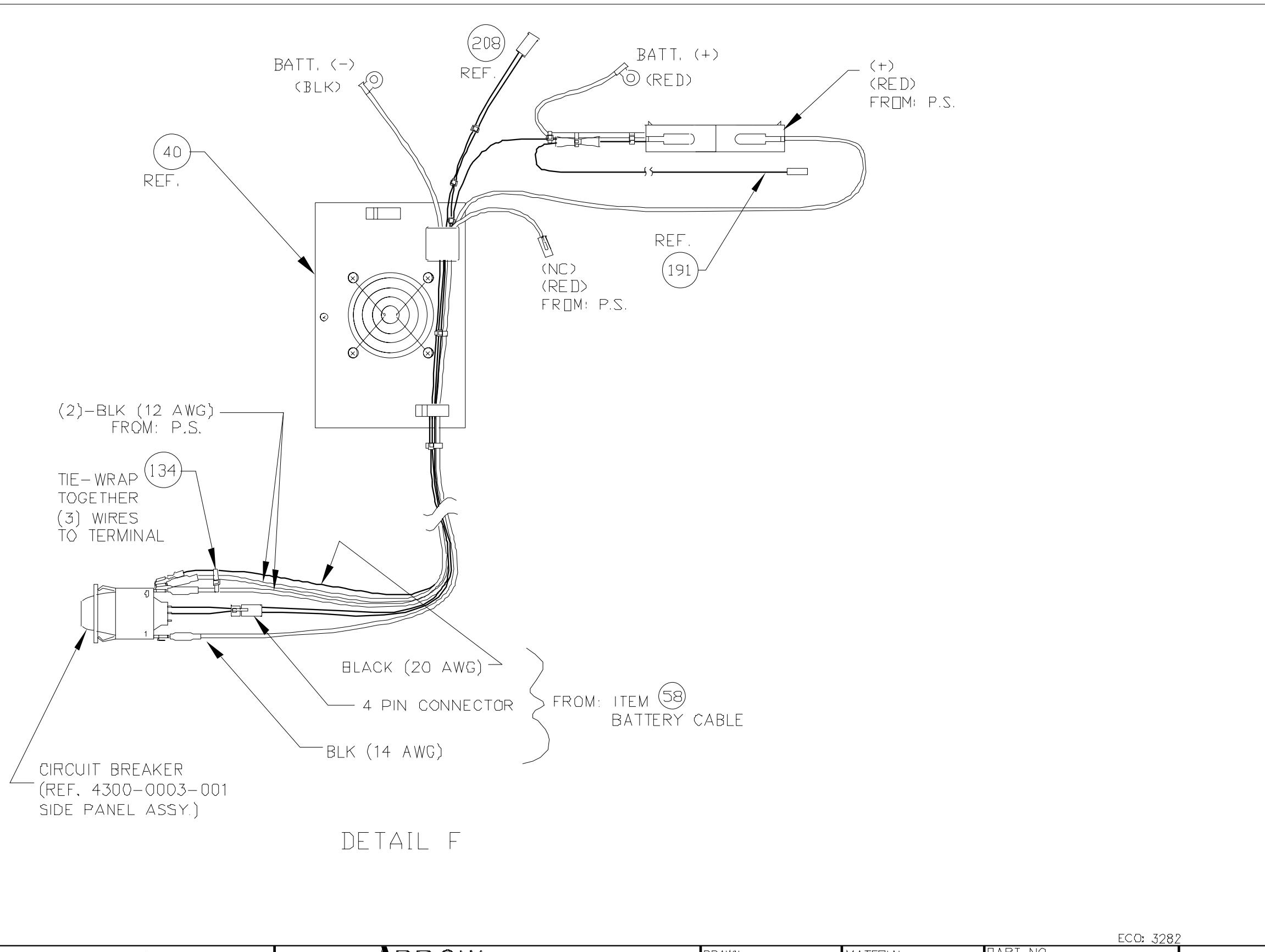
ECD: 3282

TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: $\pm .01$ FRACTIONAL DIM $\pm 1/64$ 3 PLACE DECIMALS: $\pm .005$ ANGULAR DIM $\pm 30'$ 4 PLACE DECIMALS: $\pm .0005$	ARROW INTERNATIONAL, INC. PART NAME: ASSEMBLY: AutoCAT 2 WAVE TABP	DRAWN: W.J.BOHANNON CHECKED: J.S.NAIN APPROVED: D. ETINGER	MATERIAL: SEE B.O.M. SHEET 7 OF 9	PART NO: 77-3000-001 DATE: 12/30/03	REV NO: 35 SCALE: DWG SIZE: A
---	---	--	--------------------------------------	--	----------------------------------

**Open flap to view schematic drawing  
77-3000-001 (8 of 9)**



**Open flap to view schematic drawing  
77-3000-001 (9 of 9)**



TOLERANCES UNLESS OTHERWISE SPECIFIED  
 2 PLACE DECIMALS:  $\pm .01$  FRACTIONAL DIM  $\pm 1/64$   
 3 PLACE DECIMALS:  $\pm .005$  ANGULAR DIM  $\pm 30'$   
 4 PLACE DECIMALS:  $\pm .0005$

**ARROW** INTERNATIONAL, INC.

PART NAME:  
ASSEMBLY: AutoCAT 2 WAVE TABP

DRAWN: D. WOODWARD  
CHECKED:  
APPROVED:

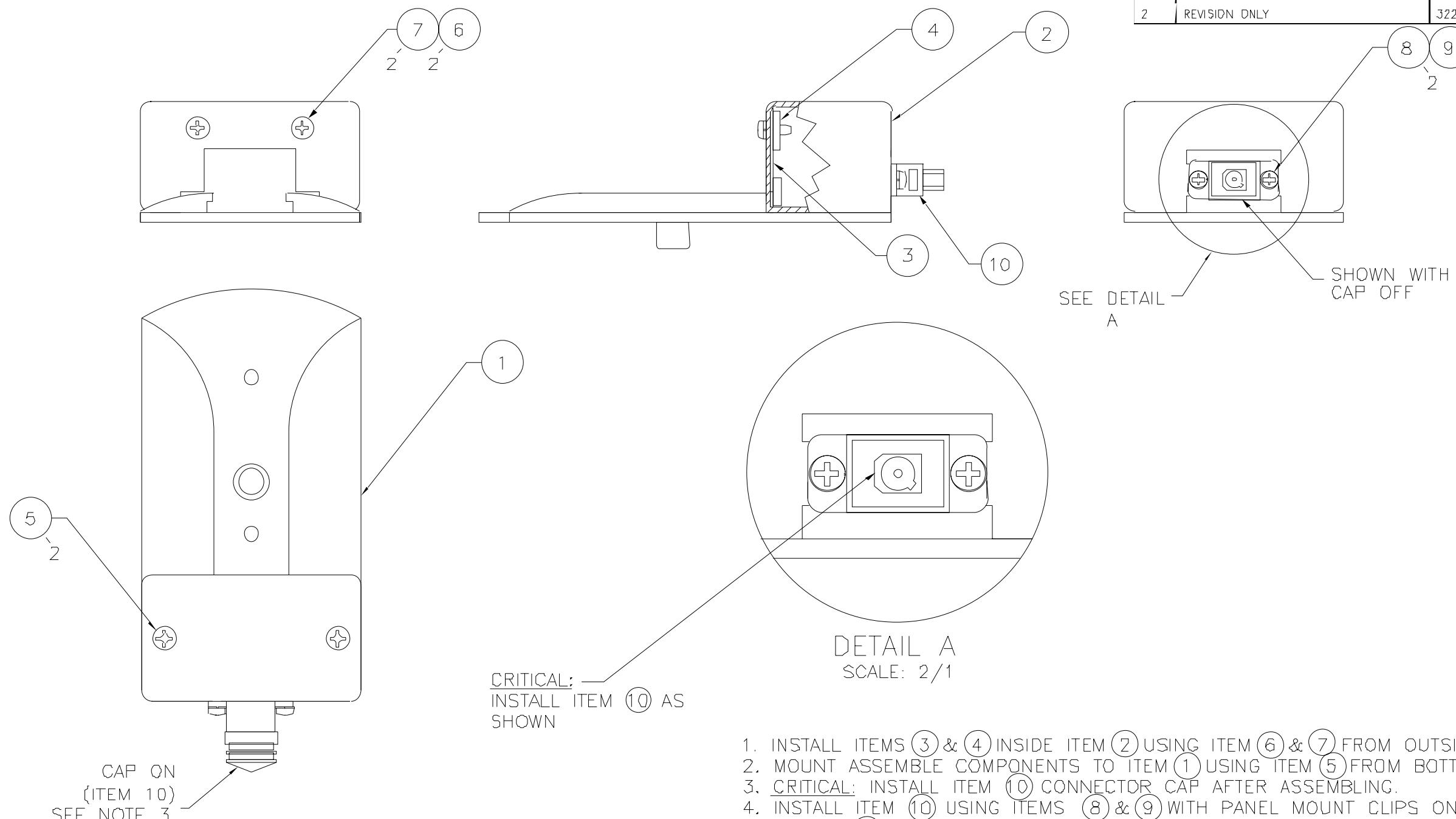
MATERIAL:  
SEE B.O.M.  
SHEET SHEET 9 OF 9

PART NO. 77-3000-001 REV NO. 35  
DATE: 01-26-04 SCALE: 1:1 DWG SIZE: A

ECO: 3282

**Open flap to view assembly drawing 77-3001-001**

REVISION HISTORY						
REV#	DESCRIPTION	ECO#	DATE	BY	ENG	CHKD
1	ADDED REV TITLE BLOCK, CHGD VIEW OF ITEM 1 TO SHOW ITEM 5 LOCATION, REVISED NOTES	2999	03/03/03	DW	BC	WB
2	REVISION ONLY	3220	11/24/03	JCS	BC	WB



1. INSTALL ITEMS ③ & ④ INSIDE ITEM ② USING ITEM ⑥ & ⑦ FROM OUTSIDE AS SHOWN.
2. MOUNT ASSEMBLE COMPONENTS TO ITEM ① USING ITEM ⑤ FROM BOTTOM SIDE.
3. CRITICAL: INSTALL ITEM ⑩ CONNECTOR CAP AFTER ASSEMBLING.
4. INSTALL ITEM ⑩ USING ITEMS ⑧ & ⑨ WITH PANEL MOUNT CLIPS ON THE INSIDE OF ITEM ②. ADJUST ALIGNMENT USING SAMPLE FOS BALLOON CONNECTOR BEFORE TIGHTENING SCREWS. TEST FOR SMOOTH OPERATION USING (3) DIFFERENT FOS BALLOON CONNECTORS. RE-ADJUST AS NECESSARY.

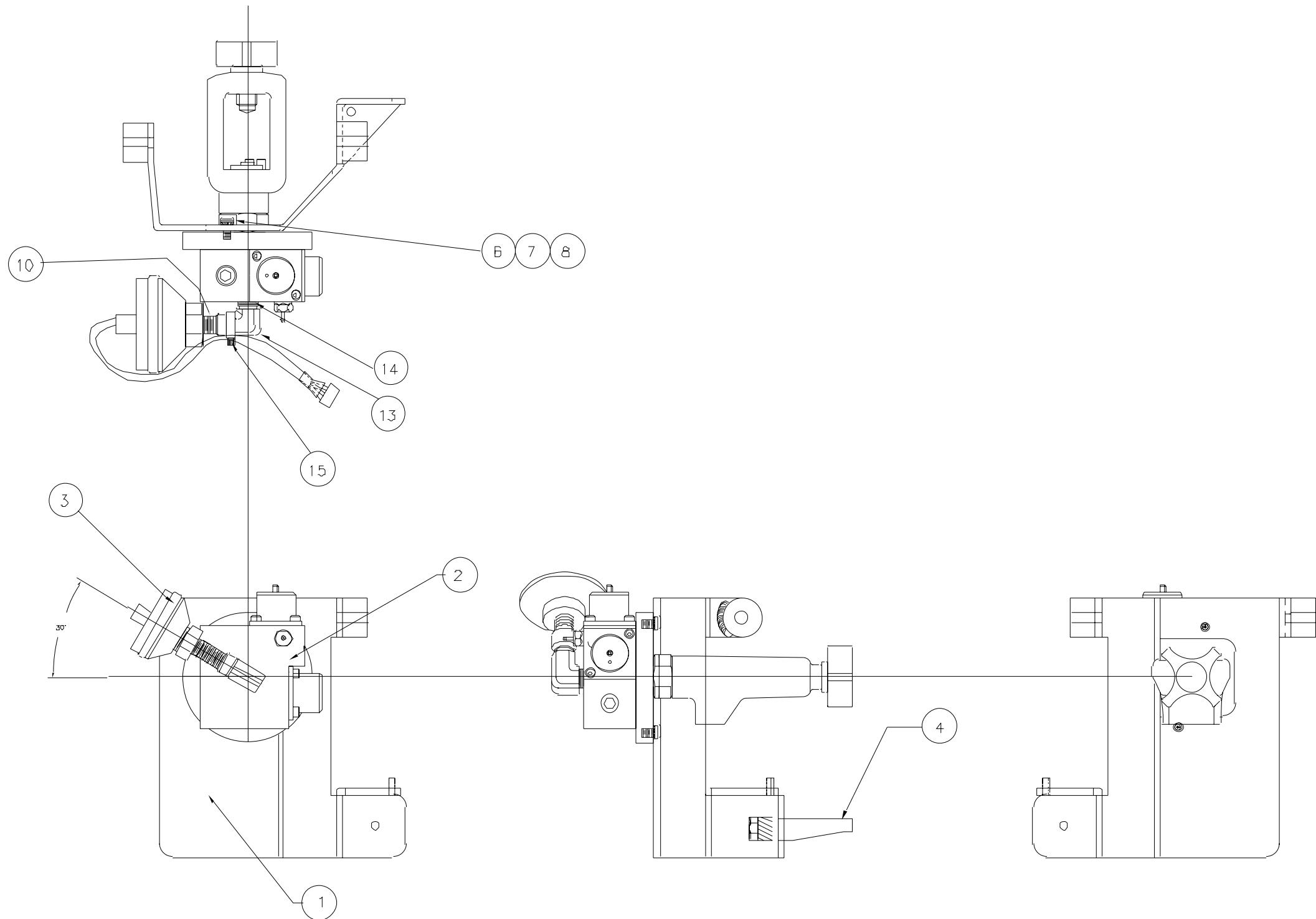
ECO: 3220

TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: $\pm .01$ FRACTIONAL DIM $\pm 1/64$ 3 PLACE DECIMALS: $\pm .005$ ANGULAR DIM $\pm 30'$ 4 PLACE DECIMALS: $\pm .0005$	ARROW INTERNATIONAL, INC. PART NAME: FOS CONNECTOR SUBASSEMBLY AUTOCAT 2	DRAWN: J. SWAIN CHECKED: W. J. EDHANNON APPROVED: B. CARTER	MATERIAL: SEE BOM SHEET SHEET 1 OF 1	PART NO: 77-3001-001 DATE: 11/24/03	REV NO: 2 SCALE: NTS DWG SIZE: B
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**8. Schematic & Assembly Drawings**

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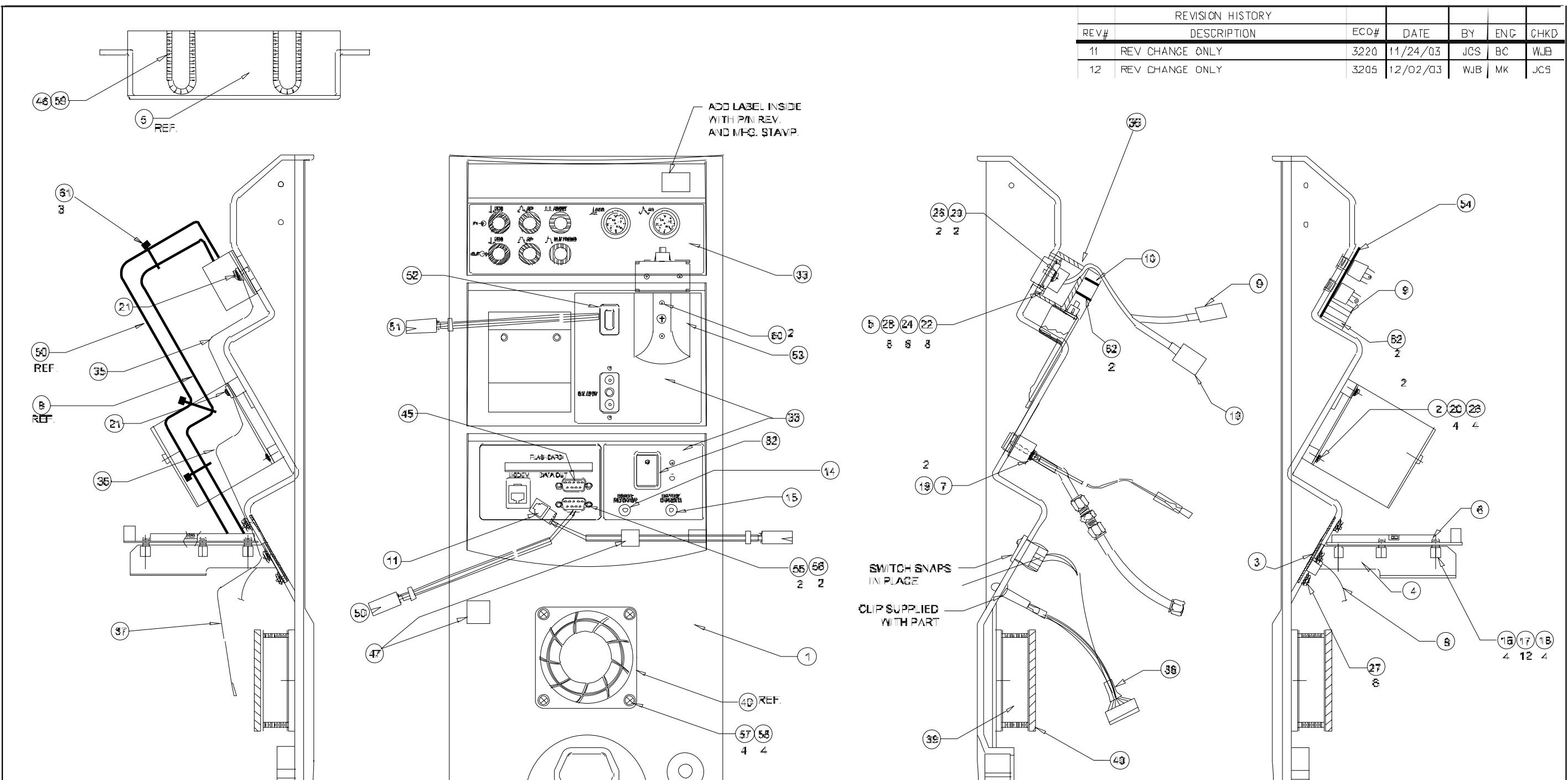
**Open flap to view assembly drawing 77-3007-001**



TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: $\pm .01$ FRACTIONAL DIM $\pm 1/64$	ARROW INTERNATIONAL, INC.	DRAWN: W.J.BOHANNON CHECKED: J. SWAIN	MATERIAL: SEE B.D.M. APPROVED: Q. FINGER	PART NO: 77-3007-001 SHEET 1 OF 1	REV NO: 0 DATE: 07/11/02	SCALE: DWG SIZE: A
3 PLACE DECIMALS: $\pm .005$ ANGULAR DIM $\pm 30'$	PART NAME: ASSEMBLY: PRESSURE REGULATOR AUTOCAT 2 SERIES					
4 PLACE DECIMALS: $\pm .0005$						

**Open flap to view assembly drawing 77-3008-001**

REVISION HISTORY						
REV#	DESCRIPTION	ECO#	DATE	BY	ENG	CHKD
11	REV CHANGE ONLY	3220	11/24/03	JCS	BC	WJB
12	REV CHANGE ONLY	3205	12/02/03	WJB	MK	JCS



ECO: 3205

TOLERANCES UNLESS OTHERWISE SPECIFIED  
 2 PLACE DECIMALS:  $\pm .01$  FRACTIONAL DIM  $\pm 1/64$   
 3 PLACE DECIMALS:  $\pm .005$  ANGULAR DIM  $\pm 30'$   
 4 PLACE DECIMALS:  $\pm .0005$

ARROW INTERNATIONAL, INC.  
 PART NAME: FRONT PANEL ASSEMBLY AUTOCAT 2 SERIES

DRAWN: W.J.BOHANNON  
 CHECKED: J. SWAIN  
 APPROVED: M. KREISMAN

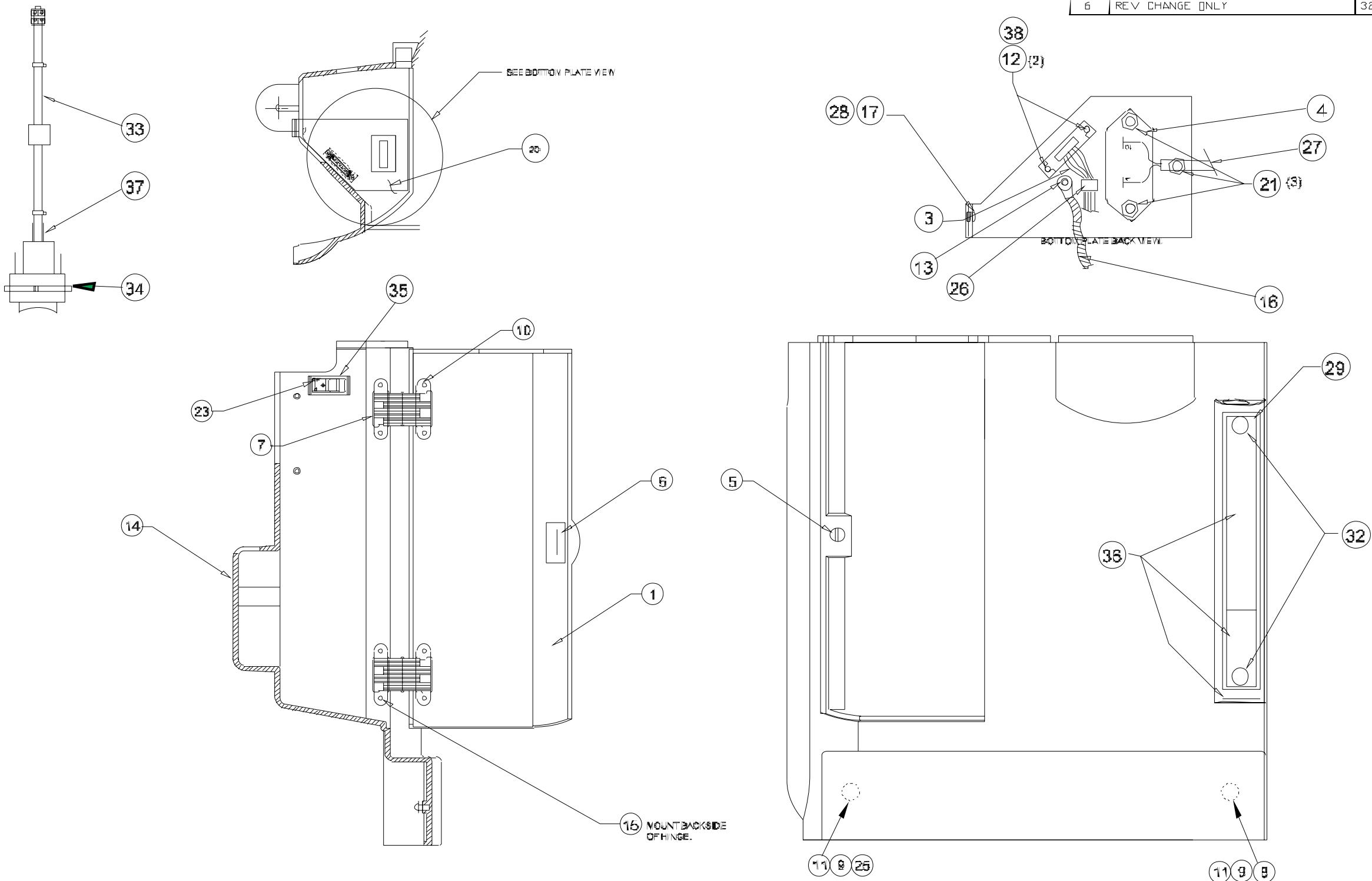
MATERIAL: SEE B.O.M.  
 SHEET 1 OF 1

PART NO: 77-3008-001  
 DATE: 11/24/03

REV NO: 12  
 SCALE: DWG SIZE: B

**Open flap to view assembly drawing 77-3009-001**

REVISION HISTORY						
REV #	DESCRIPTION	ECO #	DATE	BY	ENG	CHKD
6	REV CHANGE ONLY	3223	10/28/03	JCS	BC	WJB



ECO: 3223

TOLERANCES UNLESS OTHERWISE SPECIFIED  
 2 PLACE DECIMALS:  $\pm .01$  FRACTIONAL DIM  $\pm 1/64$   
 3 PLACE DECIMALS:  $\pm .005$  ANGULAR DIM  $\pm 30^\circ$   
 4 PLACE DECIMALS:  $\pm .0005$

ARROW INTERNATIONAL, INC.  
 PART NAME:  
 ASSEMBLY SIDE PANEL AUTOCAT 2 SERIES

DRAWN: J. SWAIN  
 CHECKED: W. BOHANNON  
 APPROVED: B. CARTER

MATERIAL: SEE B.O.M.  
 SHEET 1 OF 1

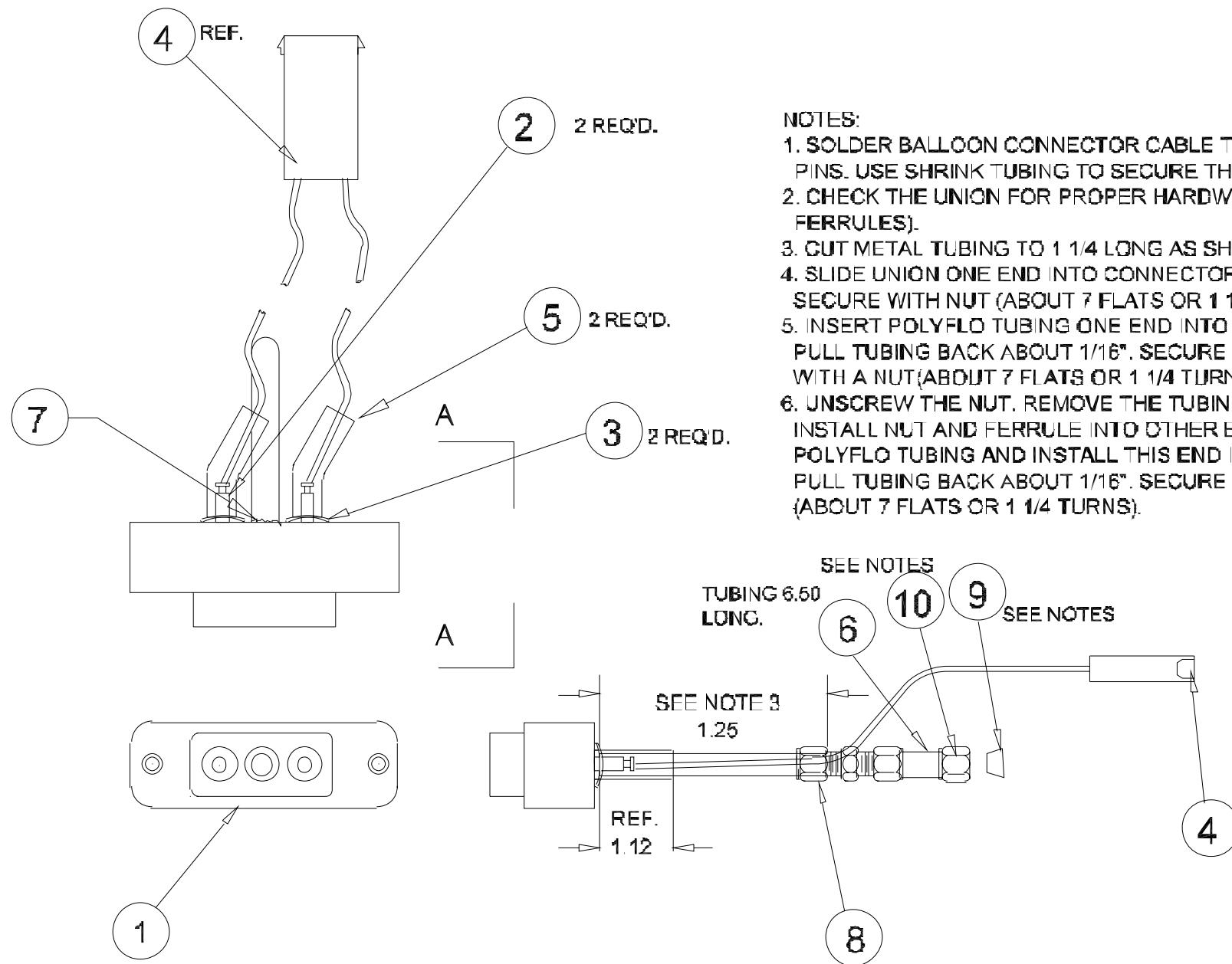
PART NO: 77-3009-001  
 DATE: 10/28/03  
 SCALE: DWG SIZE: B

REV NO: 6

**8. Schematic & Assembly Drawings**

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**Open flap to view assembly drawing 77-3012-001**



NOTES:

1. SOLDER BALLOON CONNECTOR CABLE TO INTERFACE BLOCK PINS. USE SHRINK TUBING TO SECURE THE CONNECTION.
2. CHECK THE UNION FOR PROPER HARDWARE (NUT AND FERRULES).
3. CUT METAL TUBING TO 1 1/4 LONG AS SHOWN ON DRAWING.
4. SLIDE UNION ONE END INTO CONNECTOR METAL TUBING. SECURE WITH NUT (ABOUT 7 FLATS OR 1 1/4 TURNS).
5. INSERT POLYFLO TUBING ONE END INTO UNION. PULL TUBING BACK ABOUT 1/16". SECURE THE TUBING WITH A NUT(ABOUT 7 FLATS OR 1 1/4 TURNS).
6. UNSCREW THE NUT. REMOVE THE TUBING FROM THE UNION. INSTALL NUT AND FERRULE INTO OTHER END OF THE POLYFLO TUBING AND INSTALL THIS END INTO UNION. PULL TUBING BACK ABOUT 1/16". SECURE WITH NUT (ABOUT 7 FLATS OR 1 1/4 TURNS).

ECO: 2750B

TOLERANCES UNLESS OTHERWISE SPECIFIED  
2 PLACE DECIMALS:  $\pm .01$  FRACTIONAL DIM  $\pm 1/64$   
3 PLACE DECIMALS:  $\pm .005$  ANGULAR DIM  $\pm 30'$   
4 PLACE DECIMALS:  $\pm .0005$

ARROW INTERNATIONAL, INC.

PART NAME:  
INTERFACE BLOCK ASSEMBLY AUTOCAT 2

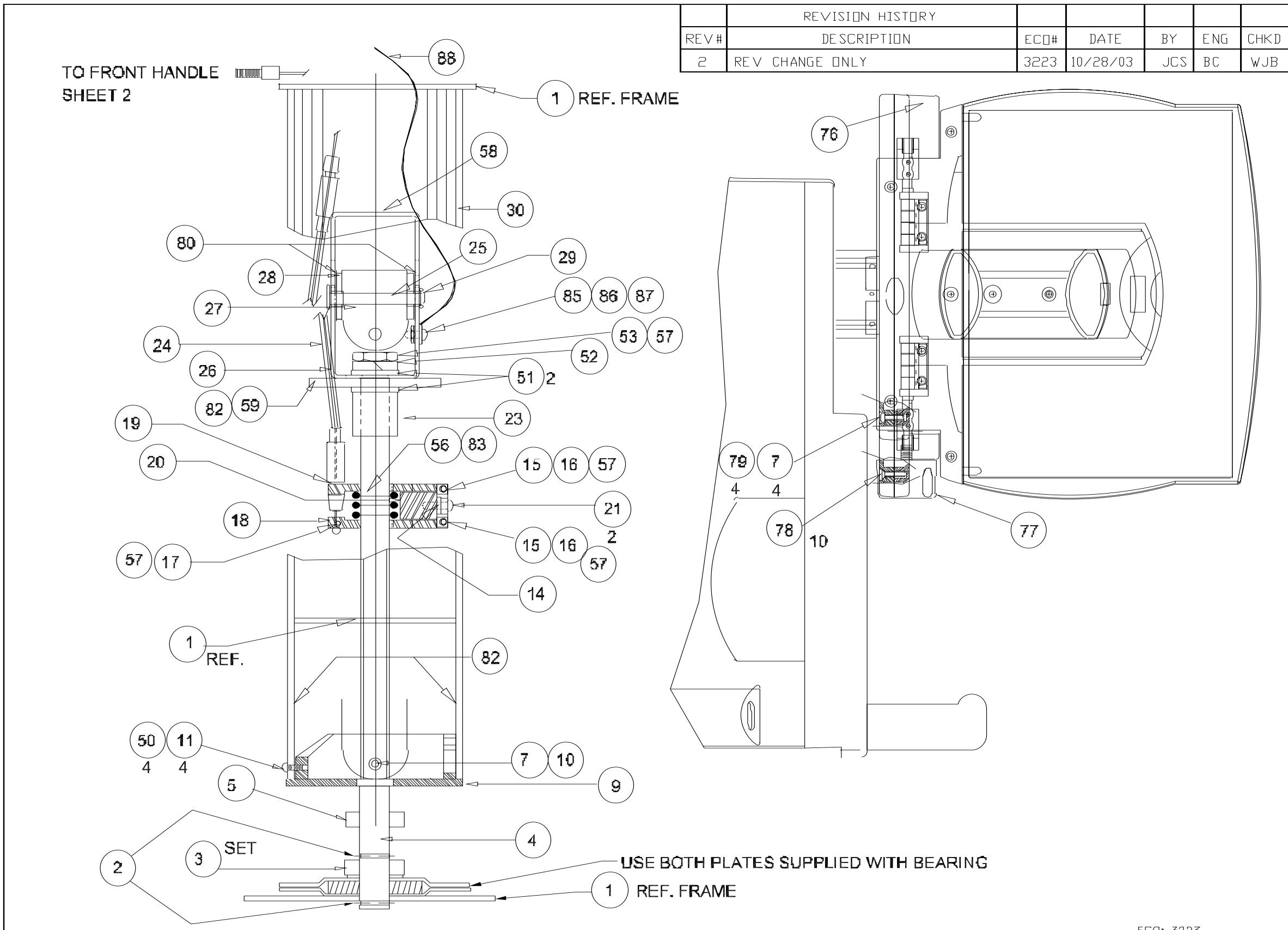
DRAWN: W.J.BOHANNON  
CHECKED: J. SWAIN  
APPROVED: B. CARTER

MATERIAL:  
SEE BOM  
SHEET 1 OF 1

PART NO  
77-3012-001  
DATE:  
07/11/02

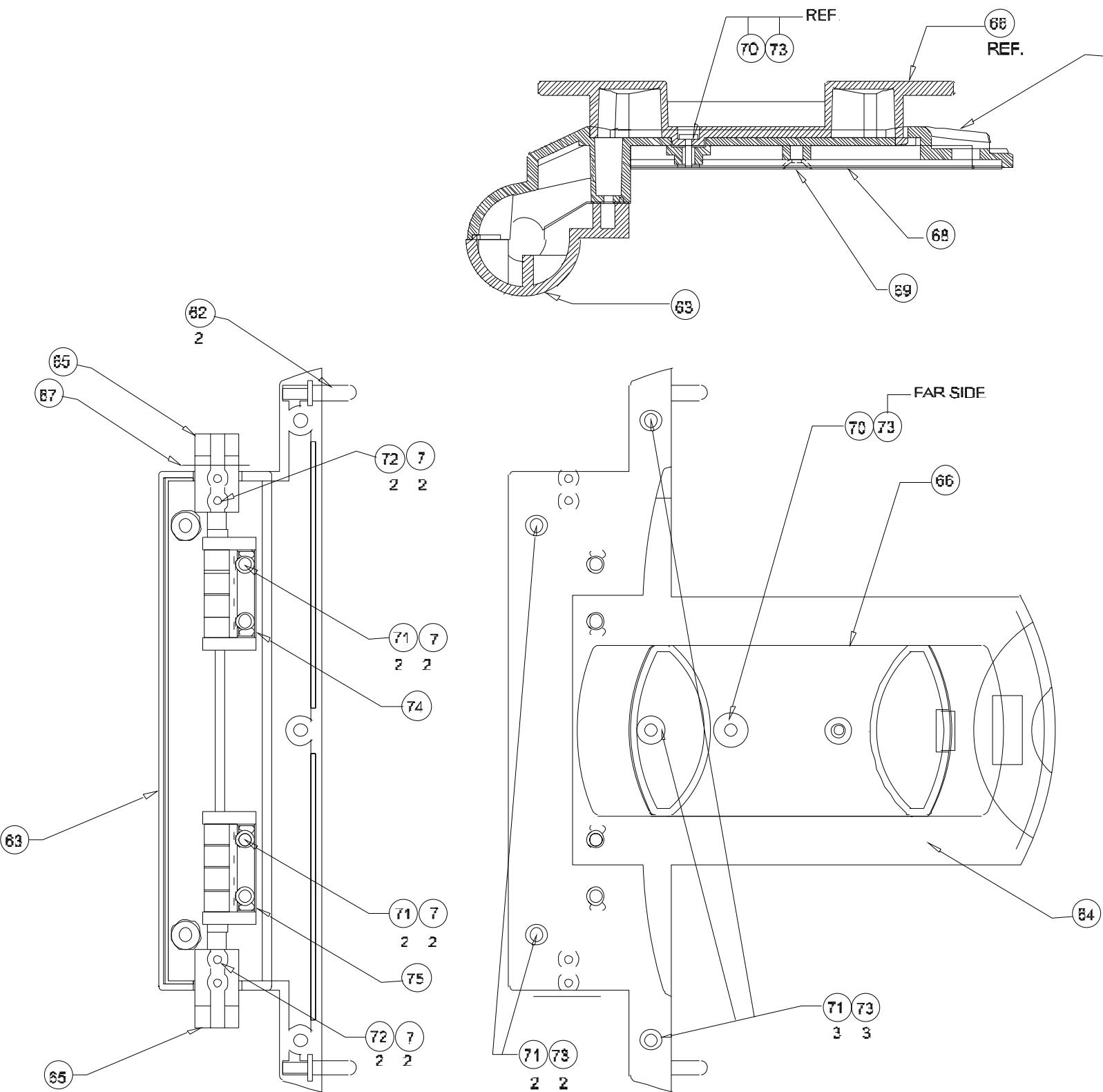
REV NO: D  
SCALE:  
DWG SIZE: A

**Open flap to view schematic drawing  
77-3014-001 (1 of 3)**



TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: $\pm .01$ FRACTIONAL DIM $\pm 1/64$ 3 PLACE DECIMALS: $\pm .005$ ANGULAR DIM $\pm 30'$ 4 PLACE DECIMALS: $\pm .0005$	ARROW INTERNATIONAL, INC. PART NAME: RAISE & LOWER MECHANISM ASSEMBLY AUTOCAD 2 SERIES	DRAWN: J. SWAIN CHECKED: W.L. BOHANNON APPROVED: B. CARTER	MATERIAL: SEE BOM PART NO. 77-3014-001 SHEET 1 OF 3	REV NO: 2 DATE: 10/28/03 SCALE: DWG SIZE: A
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**Open flap to view schematic drawing  
77-3014-001 (2 of 3)**



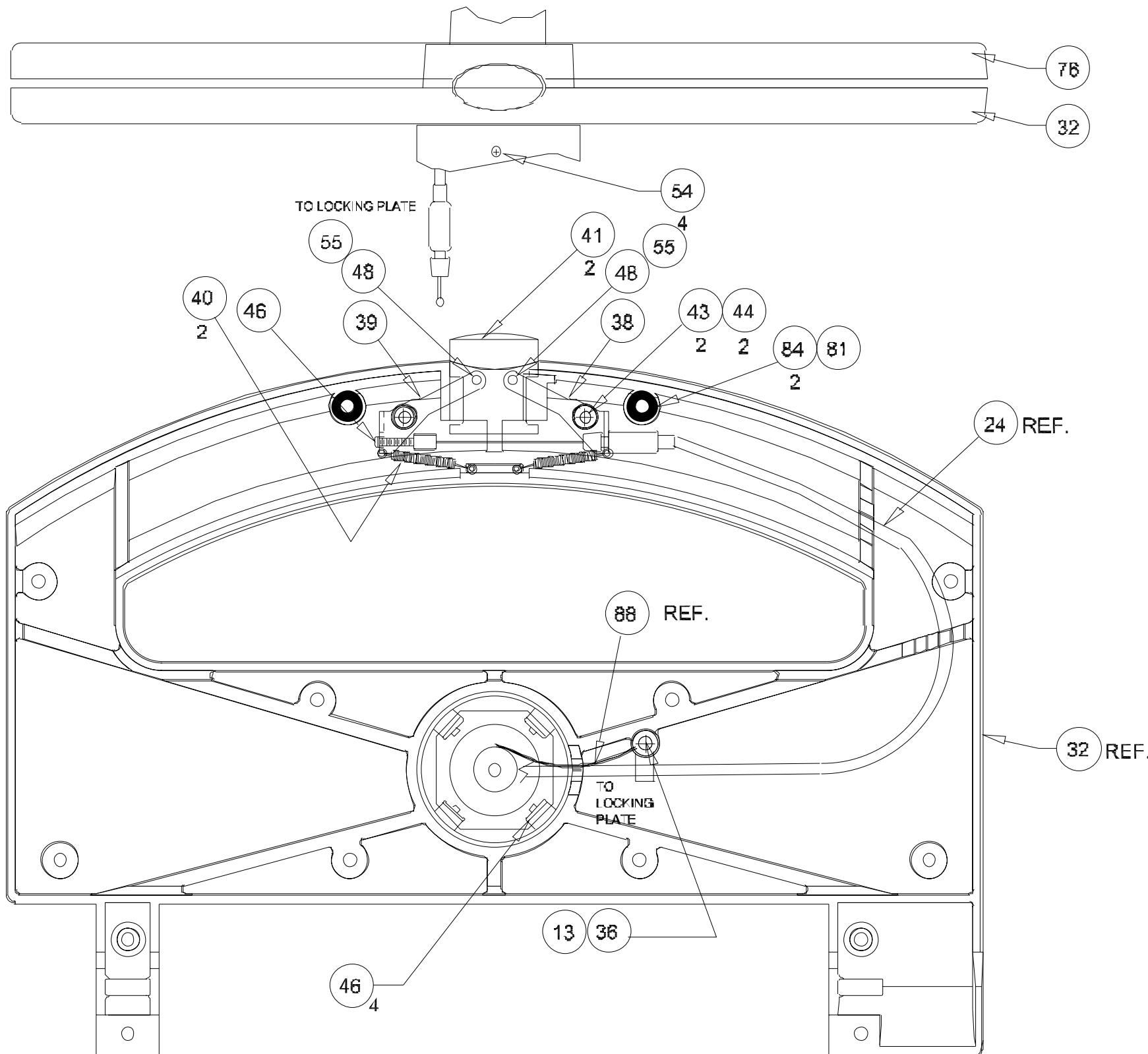
ECO: 3223

TOLERANCES UNLESS OTHERWISE SPECIFIED	
2 PLACE DECIMALS: $\pm .01$	FRACTIONAL DIM $\pm 1/64$
3 PLACE DECIMALS: $\pm .005$	ANGULAR DIM $\pm 30'$
4 PLACE DECIMALS: $\pm .0005$	

ARROW INTERNATIONAL, INC.

PART NAME:  
RAISE & LOWER MECHANISM ASSEMBLY AUTOCAT 2 SERIESDRAWN: W.J.BOHANNON  
CHECKED: J.SWAIN  
APPROVED: B. CARTERMATERIAL:  
SEE BOM  
SHEET 2 OF 3PART NO  
77-3014-001  
REV NO: 2  
DATE: 03/17/03  
SCALE: DWG SIZE: A

**Open flap to view schematic drawing  
77-3014-001 (3 of 3)**



ECO: 3223

TOLERANCES UNLESS OTHERWISE SPECIFIED	
2 PLACE DECIMALS: $\pm .01$	FRACTIONAL DIM $\pm 1/64$
3 PLACE DECIMALS: $\pm .005$	ANGULAR DIM $\pm 30'$
4 PLACE DECIMALS: $\pm .0005$	

ARROW INTERNATIONAL, INC.

PART NAME:  
RAISE & LOWER MECHANISM ASSEMBLY AUTOCAT 2 SERIES

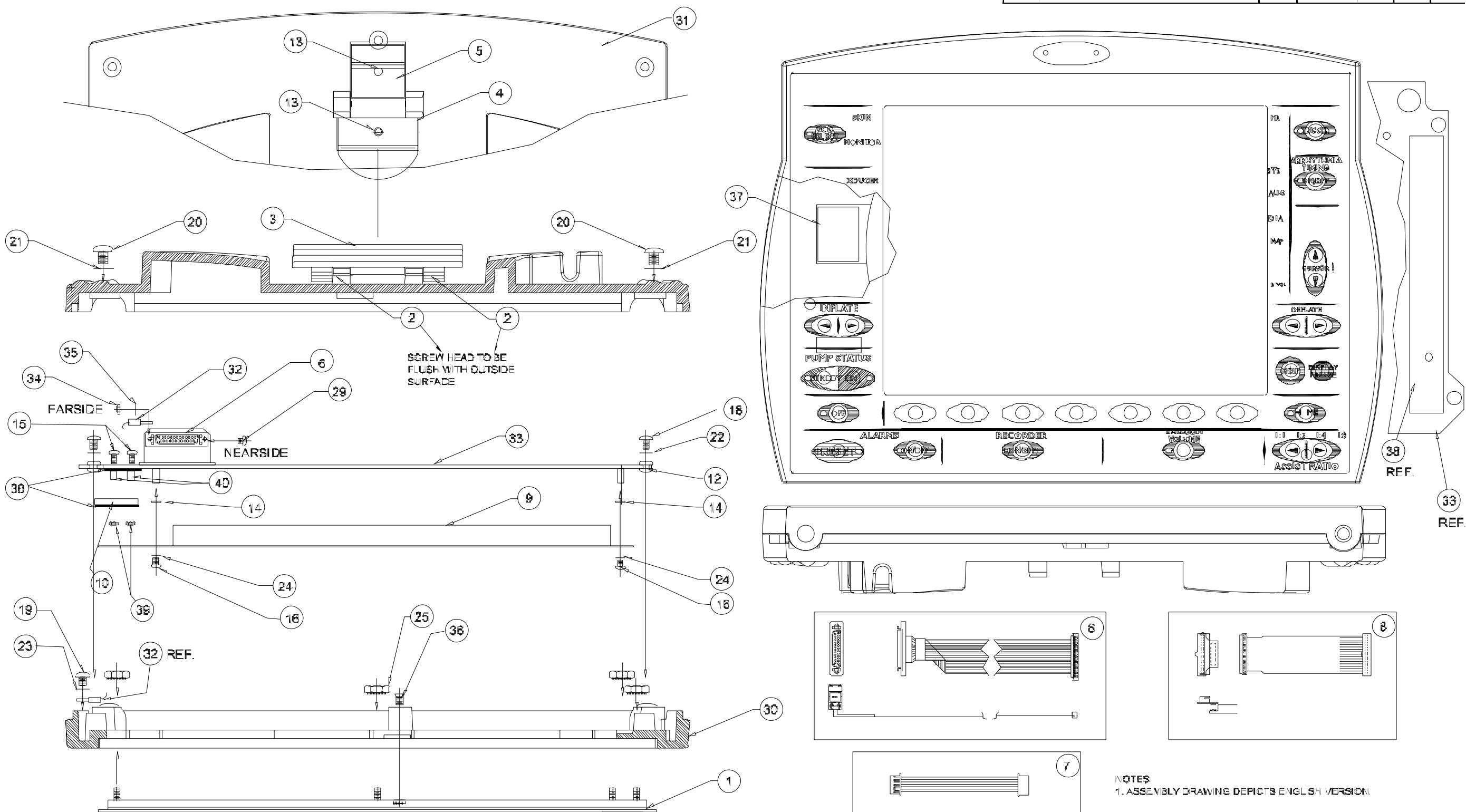
DRAWN: W.J.BOHANNON  
CHECKED: J.S.WAN  
APPROVED: B. CARTER

MATERIAL:  
SEE BOM  
SHEET 3 OF 3

PART NO: 77-3014-001  
REV NO: 2  
DATE: D3/17/03  
SCALE: DWG SIZE: A

**Open flap to view assembly drawing 77-3016-001**

REVISION HISTORY					
REV#	DESCRIPTION	ECO#	DATE	BY	ENG
8	REV CHANGE ONLY	3223	10/28/03	JCS BC	WJB



TOLERANCES UNLESS OTHERWISE SPECIFIED  
 2 PLACE DECIMALS:  $\pm .01$  FRACTIONAL DIM  $\pm 1/64$   
 3 PLACE DECIMALS:  $\pm .005$  ANGULAR DIM  $\pm 30'$   
 4 PLACE DECIMALS:  $\pm .0005$

ARROW INTERNATIONAL, INC.  
 PART NAME:  
 DISPLAY ASSEMBLY AUTOCAT 2 SERIES

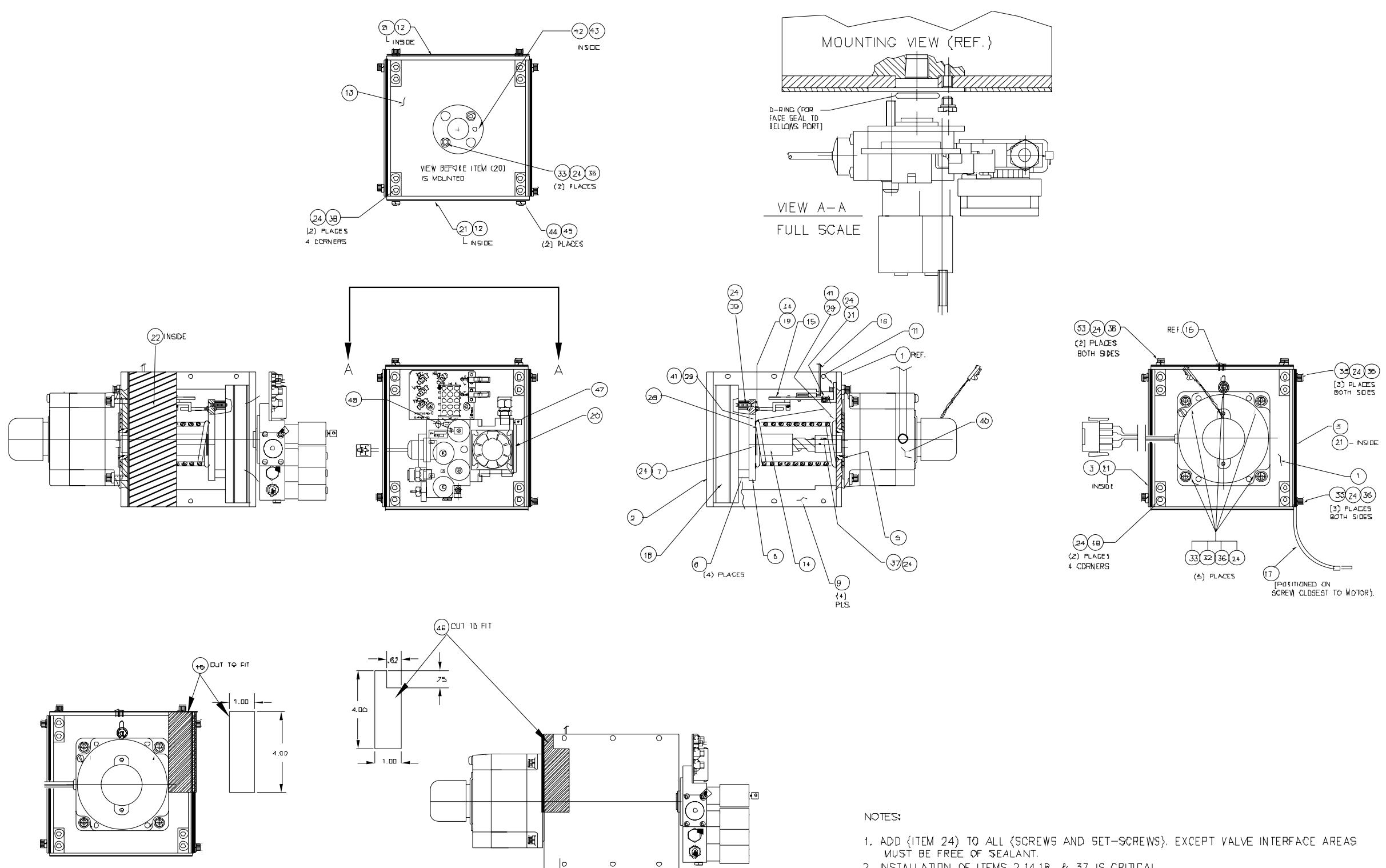
DRAWN: J. SWAIN  
 CHECKED: W.J. BOHANNON  
 APPROVED: B. CARTER

MATERIAL: SEE BOM  
 SHEET 1 OF 1

PART NO: 77-3016-001  
 DATE: 10/28/03  
 SCALE: DWG SIZE: B

ECO: 3223

**Open flap to view assembly drawing 77-3200-001**



NOTES:

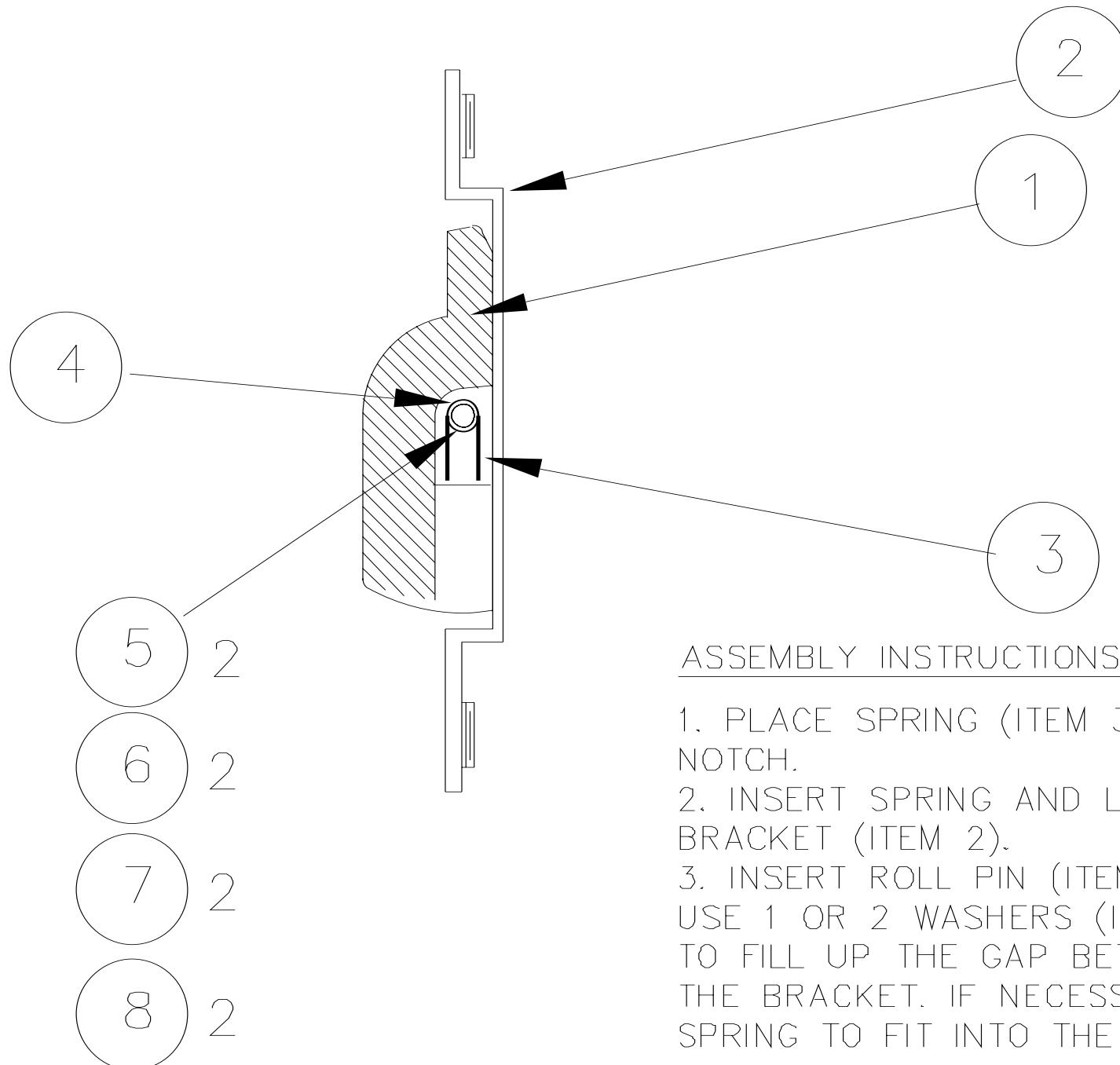
1. ADD {ITEM 24} TO ALL {SCREWS AND SET-SCREWS}, EXCEPT VALVE INTERFACE AREAS MUST BE FREE OF SEALANT.
2. INSTALLATION OF ITEMS 2,14,18, & 37 IS CRITICAL.

ECO: 3035

TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: $\pm .01$ 3 PLACE DECIMALS: $\pm .005$ 4 PLACE DECIMALS: $\pm .0005$	FRACTIONAL DIM $\pm 1/64$ ANGULAR DIM $\pm 30'$	ARROW INTERNATIONAL, INC. PART NAME: PUMP ASSEMBLY AUTOCAT 2 SERIES	DRAWN: J. SWAIN CHECKED: W.J. BOHANNON APPROVED: D. ETINGER	MATERIAL: SEE BOM SHEET 1 OF 1	PART NO 77-3200-001 DATE: 04/07/03	REV NO: 3 SCALE: DWG SIZE: B
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**Open flap to view assembly drawing 96-3019-001**

REVISION HISTORY						
REV#	DESCRIPTION	ECO#	DATE	BY	ENG	CHKD
4	REV CHANGE ONLY	3223	10/28/03	JCS	BC	WJB



#### ASSEMBLY INSTRUCTIONS

1. PLACE SPRING (ITEM 3) INTO THE LATCH (ITEM 1) NOTCH.
2. INSERT SPRING AND LATCH TOGETHER INTO THE BRACKET (ITEM 2).
3. INSERT ROLL PIN (ITEM 4) TO HOLD ITEMS TOGETHER. USE 1 OR 2 WASHERS (ITEMS 5,6,7 OR 8) AS NEEDED TO FILL UP THE GAP BETWEEN THE LATCH AND THE BRACKET. IF NECESSARY CUT THE ENDS OF THE SPRING TO FIT INTO THE NOTCH.

ECN 3223

TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE DECIMALS: ± .01    FRACTIONAL DIM: ± 1/64 3 PLACE DECIMALS: ± .005    ANGULAR DIM: ± .3° 4 PLACE DECIMALS: ± .0005	ARROW INTERNATIONAL, INC. PART NAME: ROTATION LATCH ASSEMBLY	DRAWN: J. SWAIN CHECKED: W.J. BOHANNON APPROVED: B. CARTER	MATERIAL: SEE B.O.M. SHEET 1 OF 1	PART NO: 96-3019-001 DATE: 10/29/03 SCALE: NONE	REV NO: 4 DWG SIZE: A
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### CHAPTER 9: Performance and Technical Specifications

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The AutoCAT™2 Series is a technologically advanced, microprocessor based system designed to the highest standards for performance, reliability, versatility and safety. With its computerized control system, the AutoCAT™2 Series is highly automated, freeing the clinician to provide vital care to the patient.

Chapter 3 described the operating functions of the AutoCAT™2 Series. This chapter details the AutoCAT™2 Series performance and technical specifications for your reference.

The contents of this chapter include:

<b>9.1: AutoCAT™2 Series Specifications . . . . .</b>	<b>9-3</b>
AutoCAT™2 Series Classification . . . . .	9-11
<b>9.2: AutoCAT™2 Series Classification and Symbols . . . . .</b>	<b>9-12</b>
AutoCAT™2 Series Outside Labeling Information . . . . .	9-16

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## **9. Performance and Technical Specifications**

### **9.1: AutoCAT™2 Series Specifications**

#### **AutoCAT™2 Series Specifications**

The AutoCAT™2 Series IABP System (Figure 11.1) design allows for rapid initiation of counterpulsation and is compatible with the output of most bedside monitors and direct inputs. It maintains precise IAB inflation and deflation timing based on the patient's current physiological condition, and automatically adjusts timing to accommodate variations in heart rate. The system's comprehensive diagnostic alarm system alerts the console of catheter malfunctions.



*Figure 11.1: The AutoCAT™2 Series IABP System*

The AutoCAT™2 Series technical specifications are summarized in the table on the following pages. Further discussion of the AutoCAT™2 Series performance and functions may be found in Chapter 3, Principles of Operation.

## 9. Performance and Technical Specifications

### 9.1: AutoCAT™2 Series Specifications

AutoCAT™2 Series Technical Specifications	
Dimensions	Monitor/Control Module: 9.25" high x 13.75" wide x 2.0" deep (23.5cm x 35.0cm x 5.0cm)  Pneumatic Drive Module: 28.0" high x 12.0" wide x 20.0" deep (71.0cm x 30.5cm x 51.0cm)
Weight	Monitor/Control Module: 6 lb. (2.7 kg.)  Pneumatic Drive Module: 80 lb. (36.3kg.)
Power Requirements	90-264 VAC 47-63Hz Average power consumption: 225 watts Maximum power consumption: 420 watts (surge)
Fuses	5 amp slo-blo
Battery Run Time	90 minutes (approximate, with full charge, 40 cc, 80 BPM, Assist Ratio 1:1) Optional 180 minutes with additional battery
Assist Ratios	1:1, 1:2, 1:4, 1:8
Environmental	Operating Temperature: 0°C to 45°C (without Fiber Optic Sensor) 0°C to 35°C (with Fiber Optic Sensor)
Specification	Storage and transport Temperature: -15°C to 50°C Storage and transport Atmospheric Pressure: 200 hPa - 1060 hPa (150mmHg - 796mmHg)
Pumping Rate	40-200 BPM
Lead Selection	ECG patient cable input: lead I, II or III with 4 lead cable or I, II, III, AVR, AVL, AVF, and V with 5 lead cable. From remote monitor: Phone-to-Phone
Operation Modes	AutoPilot™: Automatically selects ECG/AP signal, sources, trigger mode and timing method and settings Automatically changes settings to optimize assist.  Operator: Allows user control of most pump functions

## 9. Performance and Technical Specifications

### 9.1: AutoCAT™2 Series Specifications

AutoCAT™2 Series Technical Specifications	
Triggering Modes	ECG PATTERN, PEAK and A FIB modes <sup>1</sup> : microprocessor-based waveform comparison algorithms  ECG A PACE and V PACE modes <sup>1</sup> : <ul style="list-style-type: none"><li>– pacer recognition system triggers from pacer spikes</li></ul>
PACER DETECTION Low level (skin) ECG input	<ul style="list-style-type: none"><li>– pulse widths from 0.1 to 0.5ms and pulse amplitude of ±5 mV or greater</li><li>– pulse widths greater than or equal to 0.5ms and pulse amplitude of ±2 mV or greater</li></ul>
PACER DETECTION High level (Monitor) ECG input	Width of .1 to 2 msec and Amplitude of ≥ 1 V
Triggering Ranges	Atrio-ventricular pacing: <ul style="list-style-type: none"><li>– maximum A-V interval of 250ms</li></ul> ART PRESS mode: <ul style="list-style-type: none"><li>– microprocessor-based waveform recognition algorithm</li></ul> INTERNAL mode: <ul style="list-style-type: none"><li>– constant-rate trigger, adjustable from 40-120 bpm</li></ul> All modes except ART PRESS and A FIB: <ul style="list-style-type: none"><li>– inflation 20-80% of R-R interval</li><li>– deflation 30-120% of R-R interval</li></ul> ART PRESS mode: <ul style="list-style-type: none"><li>– inflation 0-35% of R-R interval</li><li>– deflation 35-75% of R-R interval</li></ul> A FIB mode: <ul style="list-style-type: none"><li>– inflation 80-430ms after previous R-wave deflation</li><li>– deflation on the R-wave</li></ul>
Timing Method Selection Inflation	WAVE™ Timing Automatically sets and updates inflation timing on a beat to beat basis (available with Fiber Optic IAB only)

<sup>1</sup> NOTE: Pacers automatically detected and rejected in PATTERN, PEAK and AFIB trigger modes.  
Pacers are automatically detected and used for triggering in APACE and VPACE trigger modes.

## 9. Performance and Technical Specifications

### 9.1: AutoCAT™2 Series Specifications

AutoCAT™2 Series Technical Specifications Trigger Selection Criteria (AutoPilot™ only)	
Trigger Mode	Criteria
PATTERN (Default)	HR < 130 bpm No arrhythmia detected
PEAK	HR > 130 pm Arrhythmia detected and Arrhythmia timing OFF
AFIB	HR: any Arrhythmia detected and Arrhythmia timing: ON
APACE	No ECG or AP signal available Single pacer with ECG present and time of > 100 msec from pacer upstroke to R wave and ECG/AP not stable
VPACE	No ECG or AP signal present Single Pacer with no ECG Dual pacer (A and V spike < 250 msec apart)
AP	No ECG signal available Noisy ECG signal
INFLATION TIMING METHOD Selection based on available patient signals	
WAVE™ Prediction	ECG and/or AP LightWAVE™ AP LightWAVE™ sensor
Predicted Inflation	ECG and AP Transducer/Monitor AP Transducer or Monitor
Weissler Inflation	ECG only
DEFLATION TIMING:	
Predicted deflation	ECG and AP (any Source) AP (Any source) only No Arrhythmia or Arrythmia timing OFF
R wave deflation	ECG and AP (any Source) ECG only Arrhythmia detected and Arrhythmia timing ON
Weissler deflation	ECG only Arrhythmia Timing OFF

## 9. Performance and Technical Specifications

### 9.1: AutoCAT™2 Series Specifications

#### AutoCAT™2 Series Technical Specifications

Color Display	<p>Multi-color, three-channel, high-resolution, LCD (Liquid Crystal Display),(480x640) 10.4 inch diagonal</p> <p>ECG Waveform: green; contrasting white color on assisted portions</p> <p>Arterial Pressure Waveform: red; calibrated in mmHg for direct reading, contrasting white color on assisted portion of unassisted beats</p> <p>Balloon Pressure Waveform: – blue; calibrated in mmHg for direct reading – sensed through internal strain-gauge transducer</p> <p>Timing Reference Display (Operator mode only): – Highlight displays inflate and deflate positions relative to the R-R interval (except A FIB) on unassisted beats – Color matches trigger mode and changes to yellow for deflation &gt;100%</p> <p>Waveform freeze interval: 7 seconds</p> <p>Physiological Data: – Heart Rate (HR) – Systole (SYS) – Ausmentation (AUG) – Diastole (DIA) – Mean Arterial Pressure (MAP) – Balloon Volume (B. VOL)</p> <p>Heart Rate (Beats Per Minute, BPM) – derived from ECG or Arterial Pressure triggering signals – value averaged over four beats and updated every beat</p> <p>Arterial Pressure Data (all values mmHg): – Systole (SYS) – Ausmentation (AUG) – Diastole (DIA) – Mean Arterial Pressure (MAP) – each beat sampled and pressure automatically updated every beat – Augmentation updated at each assisted beat (zero value given when no assist seen) – Assisted arterial pressure data displayed in white – Unassisted AP data displayed in yellow under assisted parameter</p> <p>Alarms: – Yellow display on bottom left display area contains alarm title and alarm specific troubleshooting information</p> <p>Help: – White text display on bottom right area of display area shows key specific operational information</p>
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## 9. Performance and Technical Specifications

### 9.1: AutoCAT™2 Series Specifications

AutoCAT™2 Series Technical Specifications	
Color Display (cont.)	<p>Key prompts:</p> <ul style="list-style-type: none"><li>- Red text in white display in bottom center display area shows current operation information</li></ul> <p>Displayed Parameter Accuracy:</p> <ul style="list-style-type: none"><li>- Heart Rate (other than internal trigger mode) +/- 2% at regular heart rhythm</li><li>- Heart rate (internal trigger) +/- 2%, +/- 2 digit at all settings</li><li>- SYS &amp; DIA +/- 2%, +/- 2 digit from 40 bpm to 120 bpm and correct inflation/deflation timing</li><li>- AUG +/- 2%, +/- 2 digit assisted beats from 40 bpm to 120 bpm and correct inflation/deflation timing; 0% unassisted beats</li><li>- MAP +/- 2%, +/- 2 digit</li><li>- Battery Voltage +/- 5%</li><li>- Balloon volume +/- 10%</li><li>- Helium supply pressure +/- 10%</li><li>- Real time clock +/- 1 minute (display resolution in minutes)</li><li>- Optional: BPW plateau pressure +/- 2%</li></ul> <p>Operating Information:</p> <ul style="list-style-type: none"><li>- helium tank pressure (auto scaling)</li><li>- alarm/battery charging status</li><li>- IAB volume (delivered)</li><li>- assist ratio</li><li>- trigger mode</li><li>- Fiber Optic Sensor Status</li><li>- arrhythmia timing</li><li>- arrhythmia timing: OFF</li></ul> <p>Trigger Signal: flashing heart symbol and white overlay on ECG</p> <p>Cursor:</p> <ul style="list-style-type: none"><li>- horizontal cursor AP/BPW waveforms</li><li>- numerical value provided</li></ul> <p>Diagnostics:</p> <ul style="list-style-type: none"><li>- alphanumeric messages indicate that potential problems exist</li></ul> <p>HELP:</p> <ul style="list-style-type: none"><li>- Context and key specific help messages show operational information</li></ul>
Strip Chart	<p>Dual-Channel Thermal Array Recorder:</p> <ul style="list-style-type: none"><li>- dot matrix with integral event marker</li><li>- records up to two of the following: ECG, Arterial Pressure, Balloon Pressure waveforms</li><li>- assist interval indicated on top margin of strip when purging and when pumping</li><li>- 40mm grid with 5mm divisions printed</li><li>- user programmable demand strips at 2,15, 30, 60 minutes and 2 and 4 hour intervals</li></ul>

## 9. Performance and Technical Specifications

### 9.1: AutoCAT™2 Series Specifications

#### AutoCAT™2 Series Technical Specifications

Strip Chart Recorder (cont.)	<ul style="list-style-type: none"><li>– assist ratio</li><li>– IAB volume delivered/ECG lead/Timing Settings/Trigger Modes/Operation Mode/AP Alarm Status/Timing Method/Assisted and Unassisted AP values</li><li>– Automatic recordings of Class 1 Alarms</li></ul> <p>Speeds: 25 or 50mm/sec. (<math>\pm 5\%</math> of rated speed)</p> <p>Paper: 50mm (<math>\pm 0.03\text{mm}</math>)-wide, blank thermal paper (Roll Diameter not to exceed 5.4cm)</p> <p>Resolution: 400 dots/inch @ 25mm/sec.</p>
Operating Gas	USP helium  <b>WARNING: Do not use oxygen or any drive gas other than USP helium.</b>
Helium Tank	Disposable 500psi canister or 2000psi refillable cylinder
Volume/Pressure Control	Closed loop system
Water Vapor Removal	Solenoid-actuated, thermo-electric baffle system removes moisture from pneumatic lines. Collection bottle can be emptied without interrupting operation.
Gas Drive	Stepper motor-driven bellows (helium gas drive only)
Pumping Volume	0.50 cc in 0.5 cc increments
ECG Low Level Filtering	Diathermy detection, 50/60Hz notch and 25Hz Low pass
Polarity	Automatic processing of positive or negative triggering signals (Arterial Pressure must be positive)
ECG Low Level Bandwidth	0.5-25Hz
Leakage Current	Less than 10 $\mu\text{A}$
Line Isolation	120 db at 60Hz to ground
Defibrillator Protection-ECG	ECG input protected up to 400 joule, 5 kV peak defibrillator discharges at 20-sec intervals. Meets IEC-60601-2-25
Defibrillator Protection-Arterial Pressure	Fiber optic signal is non-conductive. AP Transducer: Meets IEC-60601-2-34

## 9. Performance and Technical Specifications

### 9.1: AutoCAT™2 Series Specifications

AutoCAT™2 Series Technical Specifications	
Inputs and Outputs	<p>ECG MON input (high-level input): ± 5V full scale accepts ECG signals from remote monitor</p> <p>ART PRESS input: calibrated at 100mmHg/V accepts AP signal from remote monitor</p> <p>ECG MON output (high-level output): ±3V full scale provides ECG signal for display on remote monitor</p> <p>ART PRESS output: 100mmHg/V</p> <p>BALLOON PRESS output: 100mmHg/V</p> <p>ASSIST INTERVAL: TTL (used for interactive simulator connection)</p> <p>ECG (patient cable input): – for input of 4- or 5-lead patient cable – maximum input 10 mV differential</p> <p>ARTERIAL PRESSURE (transducer cable input): compatible with any pressure transducer with output equivalent to Spectramed transducer (50 µV/V/cm Hg)</p> <p>BALLOON CONNECTOR: electronic pins sense resistor value of IAB connector for input of IAB size</p> <p>DATA COMMUNICATIONS CHANNEL I: DB-9 Connector (RS232) for serial transmission of hemodynamic values, current alarms, time and date.</p> <p>SIMULATOR: DB-9 Connector (female) RS232 Model 2001 training simulator provides AC power and patient signals to pump</p> <p>MODEM: for connection to a PC via phone line for remote system monitoring</p> <p>FLASH CARD PCMCIA standard for storing data or downloading custom setups</p>
LightWAVE™ Sensor	For connection of Arrow IAB Catheter with Fiber Optic Sensor
(AutoCAT™2 WAVE only) CAL Key	Provides Fiber Optic Sensor information to IABP console CAL Key provided with each Fiber Optic IAB

## **AutoCAT™2 Series Classification**

Unit is classified as a:

- IEC60601; class 1 equipment with protection against electrical shock  
(internally powered)
- Type CF Applied parts of protection against electrical shock  
(defibrillation proof)
- IEC-529: IPX1 for degree of protection against ingress of liquids as  
(drip proof)
- Not Category AP or APG equipment (Equipment not suitable for use in the presence of flammable anesthetic mixture with air or oxygen or nitrous oxide)
- Continuous Operation

## 9. Performance and Technical Specifications

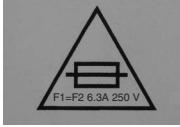
### 9.2: AutoCAT™2 Series Classification and Symbols

#### AutoCAT™2 Series Symbols and Definitions

The following pages show the symbols, and definitions of the symbols, used on the AutoCAT™2 Series IABP.

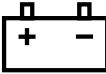
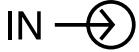
Symbol	Description
 Pb	Recycle lead
+	Plus, positive polarity
—	Minus, negative polarity
JUNC +	Plus, positive polarity
JUNC-	Minus, negative polarity
	Compliance to EMC directive 89/336/EEC
AP 	Arterial pressure signal
ECG 	ECG signal

**9. Performance and Technical Specifications**  
**9.2: AutoCAT™2 Series Classification and Symbols**

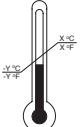
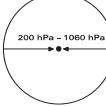
Symbol	Description
BLN PRESS 	Balloon pressure signal
	Alternating current
	Direct current
	Equipotentiality
	Attention, consult accompanying documents/refer to the manual
	“Off” (only for a part of the equipment)
	“On” (only for a part of the equipment)
	Defibrillator-proof type CF equipment
	Replace fuse as marked on front panel of IABP system

## 9. Performance and Technical Specifications

### 9.2: AutoCAT™2 Series Classification and Symbols

Symbol	Description
	Battery
	Input signal
	Output signal
	Assist interval signal for patient simulator
	Electrostatic sensitive devices
	Alarms off
	Hemodynamic data output signal
	Serial number
	Fiber Optic Icon Status Indicator

**9. Performance and Technical Specifications**  
**9.2: AutoCAT™2 Series Classification and Symbols**

Symbol	Description
	Indicates temperature range for transport and storage
	Heavy weight (usually > 40 kg)
	Fragile
	Transport and storage humidity conditions
	Handle with Care
	This way up
	Use a forklift truck to lift. The product is too heavy to lift and may cause injury or damage to product if dropped.
	Indicates atmospheric pressure range for transportation and storage

## **9. Performance and Technical Specifications**

### **9.2: AutoCAT™2 Series Classification and Symbols**

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#### **AutoCAT™2 Series Outside Labeling Information**

##### *I/O Panel:*

**DANGER: RISK OF EXPLOSION IF IN USE IN THE PRESENCE OF FLAMMABLE ANESTHETICS** label is located on the lower left corner of the I/O Panel.

**CAUTION: GROUNDING RELIABILITY CAN ONLY BE ACHIEVED WHEN EQUIPMENT IS CONNECTED TO AN EQUIVALENT RECEPTACLE MARKED 'HOSPITAL GRADE'** label is located on the lower right corner of the I/O Panel.

**SERIAL NUMBER** label which includes unit serial number and power rating is located on the lower right corner of the I/O Panel.

##### **WARNING**

RISK OF FIRE, REPLACE FUSE AS MARKED label is located on the lower left corner of the I/O Panel. Please refer to the Operator manual for replacement fuses information.

##### *Helium Compartment:*

##### **CAUTION**

HELIUM USE ONLY label is located in the helium compartment.

**FIELD CHANGE LEVEL** label which includes unit Serial Number and unit field change level number is located in the helium compartment.

**DC CIRCUIT BREAKER** for internal batteries is located in the helium compartment.

##### *Left and right side panels:*

##### **CAUTION**

TO REDUCE THE RISK OF ELECTRIC SHOCK, DO NOT REMOVE COVER, REFER SERVICE TO QUALIFIED SERVICE PERSONNEL label is located on the lower section of the left and right side panels.

##### *Battery:*

**SEALED LEAD BATTERY MUST BE RECYCLED OR DISPOSED OF PROPERLY** label contains information on the lead contents and battery ordering part number information; label is located on the battery surface.



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KEY 1	KEY 2	KEY 3	HELP MESSAGE TEXT
AUTOPilot™ MODE			
HELP			<p>1. Connect ECG and AP signals</p> <p>2. Connect balloon</p> <p>3. Press Pump on. AUTOPilot™ will automatically select Trigger, Timing settings and Signal source.</p>
HELP	AUTOPilot™		The AutoPilot™ mode automatically selects Trigger mode, timing settings and ECG/AP sources. It automatically changes these selections to maintain optimal pumping.
HELP	OPERATOR		The Operator mode gives the user full Control over all pump functions.
HELP	INFLATION TIMING		Timing set automatically in AUTOPilot™ Mode. To manually set timing, select OPERATOR mode.
HELP	DEFLATION TIMING		Timing set automatically in AUTOPilot™ Mode. To manually set timing, select OPERATOR mode.
HELP	ARRHYTHMIA TIMING		Turns automatic arrhythmia timing ON or OFF in AutoPilot™ mode only. When Arrhythmia timing is ON, the LED is lit and the pump will automatically deflate on the R wave when an arrhythmia is Detected. If OFF, the deflation will be Based on predictive timing.
KEY 1	KEY 2	KEY 3	HELP MESSAGE TEXT
OPERATOR MODE			
HELP			<p>1. Select ECG/AP signals, select source</p> <p>2. Connect balloon</p> <p>3. Select trigger mode and assist ratio</p> <p>4. Press PUMP ON</p> <p>5. Adjust timing</p>

## Appendix H: Help Text

KEY 1	KEY 2	KEY 3	HELP MESSAGE TEXT
OPERATOR MODE (continued)			
HELP	INFLATION TIMING		<p>INFLATION TIMING: Set ASSIST RATIO to 1:2. Locate DN between SYS and AUG INFLATION: Set at, or just prior to DN, so that: AUG &gt; SYS Check Deflation timing or set ASSIST RATIO to 1:1</p>
HELP	DEFLATION TIMING		<p>DEFLATION TIMING: Set ASSIST RATIO to 1:2. DEFLATION: Set deflation timing to: DIA &lt; ADIA &amp; ASYS &lt; SYS INFLATION: Set at, or just prior to DN, so that: AUG &gt; SYS Check Inflation timing or set ASSIST RATIO to 1:1</p>
HELP	TRIGGER MODE		<p>Selects Trigger in Operator mode Automatic trigger selection in AutoPilot™. To change trigger mode, select OPERATOR, then press Trigger mode. Trigger mode is selected by pressing the key under the desired trigger mode.</p>
TRIG-GER MODE	HELP	PATTERN	<p>PATTERN trigger mode. Preset trigger; for normal QRS complex. Uses height, width, and slope of positive or negative QRS complexes. Width must be between 25 and 135 mSec. Rejects pacer spikes.</p>
TRIG-GER MODE	HELP	PEAK	<p>AFIB trigger mode For any type of QRS complex and changing QRS shapes. Uses height, slope only of positive or negative QRS complexes. May be preferred for HR &gt; 140. Rejects pacer spikes.</p>

KEY 1	KEY 2	KEY 3	HELP MESSAGE TEXT
OPERATOR MODE (continued)			
TRIG-GER MODE	HELP	AFIB	PEAK trigger mode For irregular cardiac rhythms. Uses height, slope only of positive or negative QRS complexes with REAL TIME (R-Wave) deflation. Rejects pacer spikes.
TRIG-GER MODE	HELP	VPACE	VPACE trigger mode Uses V-pacer spikes to trigger, MUST BE 100% PACED. For V and AV sequential pacers. ECG SKIN cable connection recommended.
TRIG-GER MODE	HELP	APACE	APACE trigger mode Uses A-pacer spikes to trigger, MUST BE 100% PACED. For Atrial pacers only. ECG SKIN cable connection recommended.
TRIG-GER MODE	HELP	ARTERIAL PRESSURE (AP)	AP trigger mode Uses AP waveform to trigger. Recommended when ECG is not available or too noisy. NOT RECOMMENDED FOR IRREGULAR RHYTHMS.
TRIG-GER MODE	HELP	INTERNAL	INTERNAL Trigger mode: Uses IABP internal signal for triggering. Used when no ECG or APsignal is available. ASYNCHRONOUS TO PATIENT CARDIAC ACTIVITY. Press INT again to confirm.
KEY 1	KEY 2	KEY 3	HELP MESSAGE AND TEXT
MESSAGES WHICH ARE THE SAME IN AUTOPILOT™ AND OPERATOR MODES			
HELP	ECG SELECT		ECG sources are automatically selected in AUTOPILOT™. User can change LEAD, source, gain mode and level. To change source, press ECG SELECT again. LEAD label. To switch gain mode press key under desired label. Use < and > keys to adjust manual gain.

## Appendix H: Help Text

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KEY 1	KEY 2	KEY 3	HELP MESSAGE AND TEXT
MESSAGES WHICH ARE THE SAME IN AUTOPILOT™ AND OPERATOR MODES			
HELP	AP SELECT		AP SELECT provides selection for source SCALE, AP Alarm, ZERO and CAL. To change input source, press AP SELECT again. Press AP SCALING for scaling. To zero, open transducer to air and press ZERO. To CAL, input 100mmHg and adjust sens. AP alarm: MAP/AUG, press ON, set limit.
HELP	CURSOR		Moves horizontal cursor on AP and BPW. Move cursor to desired assessment point. Value is displayed above cursor on the right hand side.
HELP	ALARMS ON/OFF		Turns alarms audio, recording, drain and refill on or off. To select alarm time off, press key under desired setting. Alarm messages will still be displayed. Time remaining For alarms off is displayed above the AP Scale. Press again to turn on alarms.
HELP	RECORDER ON/OFF		Starts and stops recorder. To change recorder settings press HOME and RECORDER SETUP
HELP	BALLOON VOLUME		Select INCREASE/DECREASE until desired volume is displayed. Press FULL VOLUME to return to volume based on balloon connector. Press APPLY to change volume or Press CANCEL to cancel changes made.
HOME	HELP	AP SCALING	Press AP SCALING to select Auto or, Manual scaling. Auto ON selects AP scale which displays the entire waveform. Autoscaling OFF allows user to select AP scale which does not change. Current selection is highlighted.

KEY 1	KEY 2	KEY 3	HELP MESSAGE AND TEXT
<b>MESSAGES WHICH ARE THE SAME IN AUTOPILOT™ AND OPERATOR MODES</b>			
HOME	HELP	RECORDER SETUP	Press RECORDER SETUP to show choices. Select one or two waveforms, change speed and set timed recording. Choices are highlighted. To change, press key under selection. Waveforms cannot be changed while recording.
HOME	HELP	WEANING SETUP	WEANING SETUP sets volume, assist ratio and time for a weaning session. Select parameter and change using the < and > keys. Press START to begin weaning. A timer is displayed on the main screen. Press the 100% Vol @ 1:1 key X 2 to cancel Weaning and resume full support.
HOME	HELP	SHOW STATS	Shows AutoCAT™2 Series operational status including DATE, POWER, ALARMS, RECORDER, HELIUM tank level and ASSIST RATIO. Press HIDE STATUS to clear display.
HOME	HELP	HEMODYNAMICS	Calculates two pressure differences from patient blood pressure: (AUG - SYS) and (AUG - DIA). Calculations based on last assisted beat. Freeze/unfreeze hemodynamics for 30 seconds.
HOME	HELP	AUDIO SETUP	Audio setup adjusts key or alarm volume. You may select alarm and key volumes separately. Use SOFTER/LOUDER keys to adjust selected function. Select ALARM VOLUME then AUDIO TEST to hear alarm tone. Key clicks may be turned on or off.
HOME	HELP	CLOCK SETUP	Changes clock date and time for pump and recorder. Press key under desired parameter. Press INCREASE/DECREASE to change. Press HOME to exit.

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## Appendix: Common Abbreviations

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Many terms associated with the use of Intra-Aortic Balloon Pumping are referred to by their abbreviations. This list is provided for your reference.

<b>ADIA</b>	Assisted Diastolic Pressure
<b>AFIB</b>	Atrial Fibrillation
<b>AMI</b>	Acute Myocardial Infarction
<b>AP</b>	Arterial Pressure
<b>APSP</b>	Assisted Peak Systolic Pressure (also ASYS)
<b>ASYS</b>	Assisted Systole
<b>A/V</b>	Atrio-Ventricular (as in pacemaker)
<b>AVC</b>	Aortic Valve Closure
<b>AVO</b>	Aortic Valve Opening
<b>AUG</b>	Augmentation (also PDP)
<b>BAEDP</b>	Balloon Aortic End-Diastolic Pressure
<b>BPM</b>	Beats Per Minute
<b>BPW</b>	Balloon Pressure Waveform
<b>CAD</b>	Coronary Artery Disease
<b>CAL</b>	Calibration (as in Calibration Key)
<b>CO</b>	Cardiac Output
<b>CPP</b>	Coronary Perfusion Pressure
<b>CSA</b>	Canadian Standards Approval
<b>CVP</b>	Central Venous Pressure
<b>DIA</b>	Diastole
<b>DN</b>	Dicrotic Notch
<b>ECG (also EKG)</b>	Electrocardiogram
<b>EDP</b>	End-Diastolic Pressure
<b>ESIS</b>	Electrosurgical Interference Suppression
<b>ESU</b>	Electrosurgical Unit(s)
<b>FOS</b>	Fiber Optic Signal (also LightWAVE™)

## Appendix: Common Abbreviations

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<b>HR</b>	Heart Rate
<b>IAB</b>	Intra-Aortic Balloon
<b>IABP</b>	Intra-Aortic Balloon Pump (or Intra-AorticBalloon Pumping)
<b>IEC</b>	International Electrical Code
<b>INT</b>	Internal Trigger Mode
<b>IVC</b>	Isovolumetric Contraction
<b>IVR</b>	Isovolumetric Relaxation
<b>LAP</b>	Left Atrial Pressure
<b>LCA</b>	Left Coronary Artery
<b>LVEDP</b>	Left Ventricular End-Diastolic Pressure
<b>MAP</b>	Mean Arterial Pressure
<b>MI</b>	Myocardial Infarction
<b>MVO<sub>2</sub></b>	Myocardial Oxygen Consumption
<b>PAD</b>	Pulmonary Artery Diastolic Pressure
<b>PAEDP</b>	Patient Aortic End-Diastolic Pressure (also DIA)
<b>PAP</b>	Pulmonary Artery Pressure
<b>PCWP</b>	Pulmonary Capillary Wedge Pressure
<b>PDP</b>	Peak Diastolic Pressure (also AUG)
<b>PSP</b>	Peak Systolic Pressure (also SYS)
<b>PV LOOP</b>	Pressure Volume Loop
<b>SaO<sub>2</sub></b>	Blood Oxygen Saturation Level
<b>SV</b>	Stroke Volume
<b>SVR</b>	Systemic Vascular Resistance
<b>SYS</b>	Systole
<b>UL</b>	Underwriter's Laboratories
<b>VSD</b>	Ventricular Septal Defect
<b>WAVE</b>	Windkessel Aortic Valve Equation

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<b>Afterload</b>	The pressure which ventricular contraction must exceed to open the aortic valve; Aortic End-Diastolic Pressure
<b>Aortic Valve Closure (AVC)</b>	The onset of diastole; signaled by the DN on the AP waveform
<b>Aortic Valve Opening (AVO)</b>	The onset of systole; signaled by the beginning of the upstroke on the AP waveform
<b>Assisted Diastolic Pressure (ADIA)</b>	The lowest pressure in the aorta caused by balloon deflation
<b>Assisted Systolic Pressure (ASYS)</b>	Systolic pressure that follows IAB deflation; shows the effect on the pressure by balloon action; usually lower than the unassisted SYS
<b>Augmentation (AUG)</b>	The increase in diastolic blood pressure that occurs when balloon inflation displaces ejected blood both back toward the heart and distally toward the peripheral vasculature
<b>AutoPilot™</b>	An operations mode where most functions of the pump are controlled automatically
<b>Balloon</b>	See Intra-Aortic Balloon
<b>Balloon Pressure Waveform</b>	The waveform that depicts the pressure of helium in the balloon during each inflation and deflation cycle; displayed as the blue (3rd) waveform on the LCD
<b>CAL Key</b>	A device used with the LightWAVE™ Sensor; provides electronic information about Fiber Optic Sensor
<b>Cardiac Output (CO)</b>	The volume of blood ejected from the right or left ventricle per minute; equal to the Stroke Volume multiplied by the Heart Rate
<b>Cold Trap</b>	The internal mechanism that removes water vapor from the IAB catheter and pneumatic tubing; this water normally accumulates during IABP operation
<b>Counterpulsation</b>	The balloon-generated pulse that occurs in a cycle counter to the normal cardiac pulse; counterpulsation is controlled to increase diastolic pressure and decrease End-Diastolic Pressure
<b>Diastole (DIA)</b>	The phase of the cardiac cycle in which most coronary perfusion and ventricular filling occur
<b>Diastolic Pressure (DIA)</b>	The lowest pressure normally occurring in the aorta; diastolic pressure

## Glossary

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<b>Dicrotic Notch (DN)</b>	The notch on the downslope of the AP waveform that signals AVC and the onset of diastole; caused by the backflow of blood as the pressure in the ventricle falls below that in the aorta
<b>Ejection</b>	The bolus of blood forced out of the heart and into the aorta by ventricular contraction
<b>Electromechanical Delay</b>	The difference in time between electrical events of the heart (e.g., ventricular depolarization) and the resulting mechanical event (e.g., ventricular contraction)
<b>Electro-Surgical Interference Suppression (ESIS)</b>	A filtering function to minimize interference on the ECG waveform caused by electrosurgical or electrocautery devices
<b>Fiber Optic</b>	A light signal that measures Arterial Blood Pressure; also known as LightWAVE™ Sensor
<b>Filling</b>	The collection of blood in the ventricles prior to isovolumetric contraction
<b>Flash Card</b>	PCMCIA standard for storing data or downloading custom setups
<b>Heart Rate (HR)</b>	The number of cardiac cycles per minute
<b>Intra-Aortic Balloon (IAB)</b>	The balloon-tipped catheter used for counterpulsation; also called balloon
<b>Isovolumetric Contraction (IVC)</b>	The phase of the cardiac cycle in which ventricular volume remains unchanged while the left ventricle contracts; enough pressure is generated to overcome aortic pressure (afterload) and cause Aortic Valve Opening
<b>Isovolumetric Relaxation (IVR)</b>	The phase of the cardiac cycle in which most coronary perfusion and ventricular filling occur
<b>LCD</b>	The waveform display that displays the ECG, AP and balloon pressure, as well as physiological data, operating instructions and alarm messages
<b>Mean Arterial Pressure (MAP)</b>	A measure of Arterial Blood Pressure determined by calculating the area under the curve of the Arterial Pressure Waveform
<b>Nicolay</b>	The manufacturer and type of connection made to the AutoCAT™2 when using ECG skin cables or pressure transducers

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<b>Operator Mode</b>	The mode of pump operation where the user can control all pump functions
<b>Quality Assurance log</b>	Time stamped record of IABP operations including alarms, hemodynamics and operational settings
<b>Peak Diastolic Pressure (PDP) also AUG</b>	The highest aortic pressure generated by balloon inflation; augmented diastole or augmentation; usually higher than PSP
<b>Systolic Pressure (SYS)</b>	The highest aortic pressure produced by ventricular ejection; systolic pressure
<b>Phono-to-Phono</b>	The cable used to connect signals from a patient monitor to the AutoCAT™2 Series
<b>Predictive Timing</b>	A timing method where the inflation and deflation points are based on the prior beat
<b>Preload</b>	Ventricular End-Diastolic Volume; measured as LVEDP=PCWP=PAD
<b>Pulse Rate</b>	The number of pressure pulses per minute; during counterpulsation, equals PSP plus PDP, and the effective pulse rate is twice the Heart Rate (when in 1:1 assist ratio)
<b>Pulse Pressure</b>	The mechanical pulse felt by systemic circulation; during counterpulsation, PDP is often higher (or noted before) BAEDP, affecting pressure readings by cuffs and monitoring equipment
<b>Rapid Ejection Phase</b>	The phase of ventricular ejection from just after AVO through PSP (the upstroke on the AP waveform); produces approximately 75% of SV
<b>Real Time Timing</b>	The method where inflation occurs at the DN and deflation is set to occur with early systolic ejection; also known as R Wave deflation
<b>Stroke Volume (SV)</b>	The volume of blood ejected by the heart during a single systole
<b>Systolic Runoff</b>	The phase of ventricular ejection characterized by a downslope of the AP waveform, between PSP and the Dicrotic Notch; produces approximately 25% of SV
<b>Systolic Unloading</b>	The reduction of afterload seen as a reduction in PSP; however, depression of systolic ejection is also seen as a reduction in PSP
<b>Timing</b>	The synchronization of the balloon-generated pulse with patient hemodynamics; controlled by the IABP operator

## Glossary

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<b>Timing Method</b>	The logic which determines how to set inflation and deflation timing
<b>Trigger</b>	The signal used by the IABP to activate the inflation/deflation cycle; signal may be patient-generated (ECG or AP) or control system-generated (INTERNAL)
<b>WAVE</b>	A unique timing method based on the Windkessel model; determines the AVC point and sets inflation timing to occur at that point
<b>Weissler Timing</b>	A method where the Systolic Time Interval (STI) is calculated based on HR; inflation and deflation timing is set to occur at the end of Systolic ejection and just prior to next Systolic upstroke; used when ECG only is available

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