Resolver Installation Considerations

For

The SignatureACE™ and SmartSAM™ Systems

3rd revision 7/29/97

SIGNATURE TECHNOLOGIES

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Printed in U.S.A.

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GENERAL Information:

This write-up is intended to provide information on what is required in order to properly mount and drive a Signature Technologies Resolver.

While it is impossible to enumerate all the possibilities, several illustrations are provided of common types of mountings.

Signature Technologies always stands ready to provide installation support all the way from a helpful phone call, to a turnkey installation, and anywhere in between. Normally in order to design a resolver drive, very specific information is needed about the machine.

A concept can be arrived at with nothing more than photographs of the machine, but a complete design depends of having quantitative information. For example, the end of the crankshaft on a straight side press probably has a tapped hole that could be used for the installation of a drive stub. Before the stub could be designed though, the size of the hole and its thread configuration would have to be known before the stub could be designed.

The information needed is easy to come by if the machine is sitting in your facility, but must be transmitted to a designer who works off site.

Normally, if Signature Technologies Inc. is to be involved in installation design, at least one trip to the customer's site previous to the start of application design, or delivery of materials will be required. The trip will be made in order to take the measurements that will be required, and visually inspect the proposed application for feasibility.

Alternatively, if the installation is really simple, we can try to work from information supplied to us by the customer (sample worksheet is included at the back of this publication).

When working from customer supplied specifications; however, Signature Technologies Inc. will not accept the responsibility for, or any penalty resulting from, installation problems resulting from the existence of obstructions, clearance situations, or dimensional incompatibilities resulting from inaccurate, or missing data from the customer.

MOUNTING REQUIREMENTS:

The function of the resolver in the Signature Technologies Inc. signatureACE™ / SmartSAM™ system is the provision of positional information, generally of a rotary type, to the SAM500 Statistical Analysis module. The data from the machine process is gathered based on the positional signals that the resolver produces. If the resolver data is an accurate representation of actual machine motion, the signature data produced thereby will accurately reflect the process status. If there are differences in the position data caused by rotary vibration, lost motion, or drive inaccuracies, the Signature data will be flawed and sensitivity to process changes will be lost.

The primary thing we are always after is a torsionally rigid connection between the press CRANKSHAFT, and the Resolver. Preferably, the resolver will be driven directly by the crankshaft through a flexible coupling to absorb radial and axial movement of the crankshaft.

While the resolvers who are used with programmable limit switches, and stroke position auxiliaries are often hooked in behind the Cam Limit Switch, our resolver must not be mounted this way. A programmable switch normally runs at 1-2 degree accuracy, and generally not more than 0.36 degrees of basic resolution. This type of accuracy is fine for programmable switches, but is well outside the requirement for Signature Analysis activities. The SAM500 module operates normally at 0.088 degrees resolution, and any inaccuracy in the resolver drive will immediately show up as horizontal migration in the signature. The process limits must be widened to accommodate any horizontal migration, thus reducing the sensitivity of the Signature Analysis system to actual process variations, which may be smaller than the mechanical uncertainty of the resolver drive system.

NOTE:

The resolver unit is an industrial package, with excellent specifications as are listed on the next pages. It is, however, a precision instrument, and must be treated as such if proper service is to be obtained.

NEVER strike the resolver shaft in any way from any direction. This includes DRIVING ON pulleys or couplings that are more than a push fit on the shaft. The 95-pound limit on the shaft end is really easy to exceed when driving a coupling on with a hammer. In general if it's too tight to slip on by hand IT'S TOO TIGHT! Open the bore before installing it.

NEVER install belting by "Stretching" it over the pulley edge without loosening the adjustment. This can overload the bearings and cause premature failure.

NEVER Over-tighten the drive belt. Tighten only until there is no perceptible slack. Belt deflection under light finger pressure should be in the 3/8" to 1/2" range.

NEVER modify the resolver shaft. Machining, drilling, or other modification of the resolver shaft VOIDS THE WARRANTY.

We don't recommend couplings or pulleys that affix using a setscrew, unless the pulley/coupling has a properly fitted key, and the setscrew bears down on the key surface. It's generally better and more reliable to use CLAMP Hubs.

Resolver Physical Specifications:

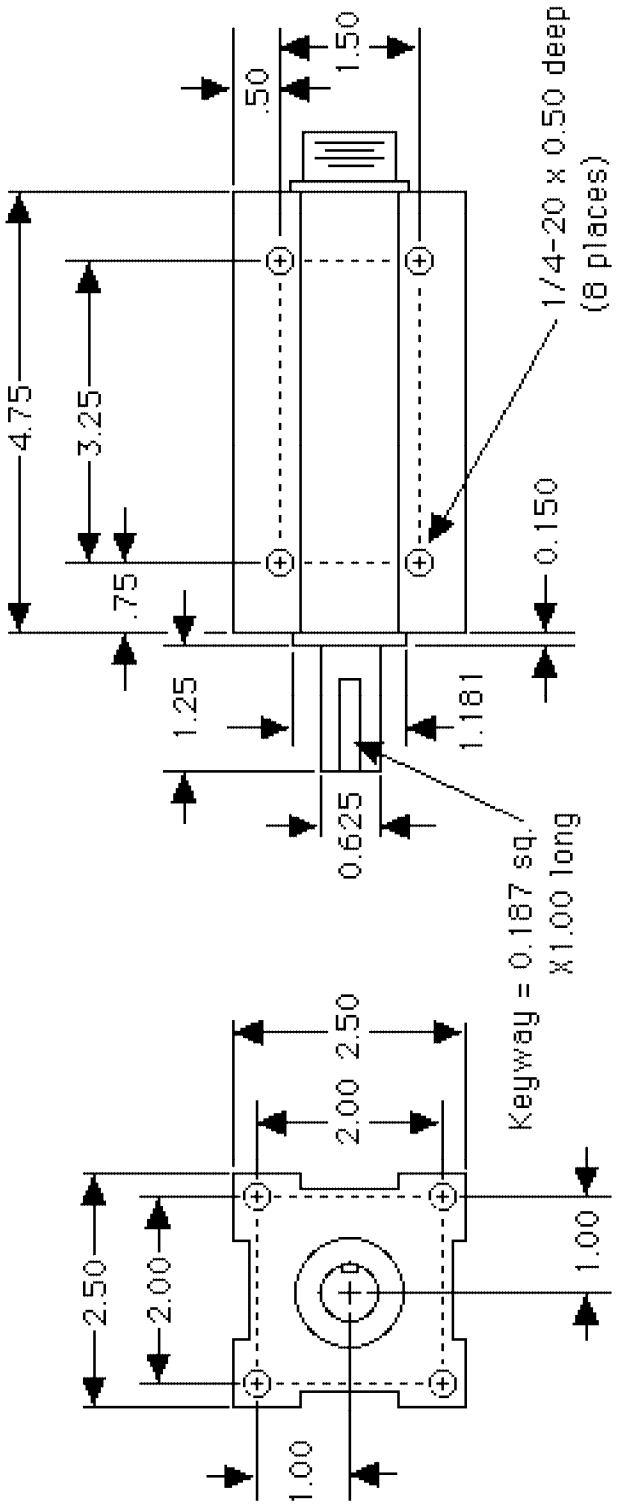

Figure # 1 - S.T.I. Standard Resolver Package

Resolver Mechanical / Environmental Specifications:

Max. Starting Torque .....3.0 Oz-In
Moment of inertia .....15Gm-Cm^2 / 0.08199 Oz-In^2
Max. Slew speed .....3000 R.P.M.
Max. Shaft loads
    Axial.....95 Lbs.
    Radial .....400 Lbs.
Weight.....2.5 Lbs.
Shock tolerance.....50G for 11 Msec.
Vibration tolerance.....15G to 2000 Hz.
Operating Temperature .....-20° C to +125° C
Radiation.....10^6 Rad
Protection .....NEMA 4

Do's and Don'ts:

NEVER drive the resolver by coupling to the extension shaft of a mechanical rotary cam limit switch. Mechanical cam limit switches normally throw bi-directional torque spikes into the drive system that they are connected to. This can cause as much as +/- 3 degrees of uncertainty in the resolver drive.

NEVER drive the resolver by coupling to shafting driven by general-purpose right angle gear drives. Right angle gear sets of the type normally used in auxiliary normally have a large amount (relatively) of back lash new, and this backlash only gets worse as the drive wears.

NEVER drive the resolver with a roller chain. Roller chains stretch and develop loads of play rapidly. You can expect 2-3 degrees of uncertainty from a roller chain drive after a little wear.

NEVER strike the Resolver shaft with a hammer or other appliance. If the pulley or coupling you are trying to use won't slip on the shaft by hand **IT'S TOO TIGHT!** Relieve the bore a little so it slides on. Premature resolver failure will result from shaft abuse. See the list of warnings on page #6

NEVER drive the resolver with a coupling that doesn't tolerate **Parallel Misalignment**.

We **DON'T RECOMMENDED** driving the resolver from auxiliary shafting driven by Timing Belt drive from the Crankshaft. Timing Belt drives are tighter, but normally shows (in the larger sizes) as much as one degree of uncertainty. In addition, even though there is essentially no

"backlash" in a Timing Belt drive, there is some stretch, which translated to positional uncertainty if a variable torque load (like an indexer or a roller cam feed) is being driven. On the other hand, torque induced positional uncertainty in a Timing Belt drive tends to be repeatable from revolution to revolution and may not constitute a serious problem. The user should be aware, however, that his position reference might be distorted by several degrees at certain points of the rotation.

We **DON'T RECOMMEND** driving the resolver with any Timing Belt drive where the sprockets are smaller than 4" in diameter. This is because as the sprocket diameter gets smaller, the positional uncertainty at the resolver resulting from tooth clearance gets larger. Normally, only one of the sprockets will require flanges for belt guidance.

We **APPROVE OF** resolver drives that couple directly to the crankshaft through a flexible coupling. The simplest coupling **where there is NO end float** in the crankshaft is a 3" piece of hydraulic hose applied with worm drive hose clamps. Better are the machined aluminum "Helical" type couplings (like MICRON, or HELICAL). In cases of extreme end float the disk type coupling (like RENBRANDT) is a good bet.

We **APPROVE OF** resolver drives that use type "XL" (0.200 pitch) or 3.5"or greater diameter type "L" (0.375 pitch) Timing Belt drive systems from the crankshaft. These are slightly less accurate than direct coupling, but still very acceptable. In this case watch for radial play in the crankshaft to avoid over stretching and possible damage to the drive belt and resolver bearings.

We **APPROVE OF** resolver drives from the auxiliary drive shafts on larger machines, as long as the ST Resolver drive is either directly coupled to the auxiliary drive gear shaft, or Timing Belt driven from it before any additional coupling or gearing is done. The auxiliary drive system on larger presses is generally not "ultra tight" but due to the large diameter of the gears, and a lot of flywheel effect, they still have a relatively good accuracy. We want; however, to be driven right from the auxiliary source, without any interposed gearing or couplings that can generate play. On larger machines, this is often the only alternative for resolver drive since the shafts that carry the drive cams don't turn.

DESIGN PRACTICES:

In general, you should go for rigidity, and very low torsional compliance in the resolver drive.

The primary thing that you want to accomplish is that the resolver shaft should always move in total synchronism with the crankshaft (or other final drive element) of your machine.

Mounting the resolver:

It is not necessary to shock mount the resolver in any but the most brutal applications.

The Resolver has mounting provisions on its **SIDE surface** for four 1/4-20 mounting bolts, we suggest this as the preferable method. The screws should be installed with medium strength Loctite™ to prevent loosening.

It is generally a good idea **NOT to** use END mounting for the unit even though provision has been made for it. END mounting tends to produce a large cantilevered load on the mounting screws which will be likely to cause them to loosen in the long run, It will also cause amplified vibration at the connector end of the resolver unit that is not good for either connector or cable life.

Resolver cable control:

The mounting bracket should be designed with provision for tying down the resolver cable within 6-8 inches of the connector so excessive lengths are not allowed to wave in the breeze. Simply attaching the cable to the bracket with drilled holes, and tie-wraps can prevent a lot of cable maintenance in the long run.

Driving the resolver from the END of the crankshaft:

If the end of the crankshaft is unencumbered with feed drive or auxiliary apparatus, and there is a solid surface to mount the resolver bracket to, we prefer to end drive the resolver as illustrated below.

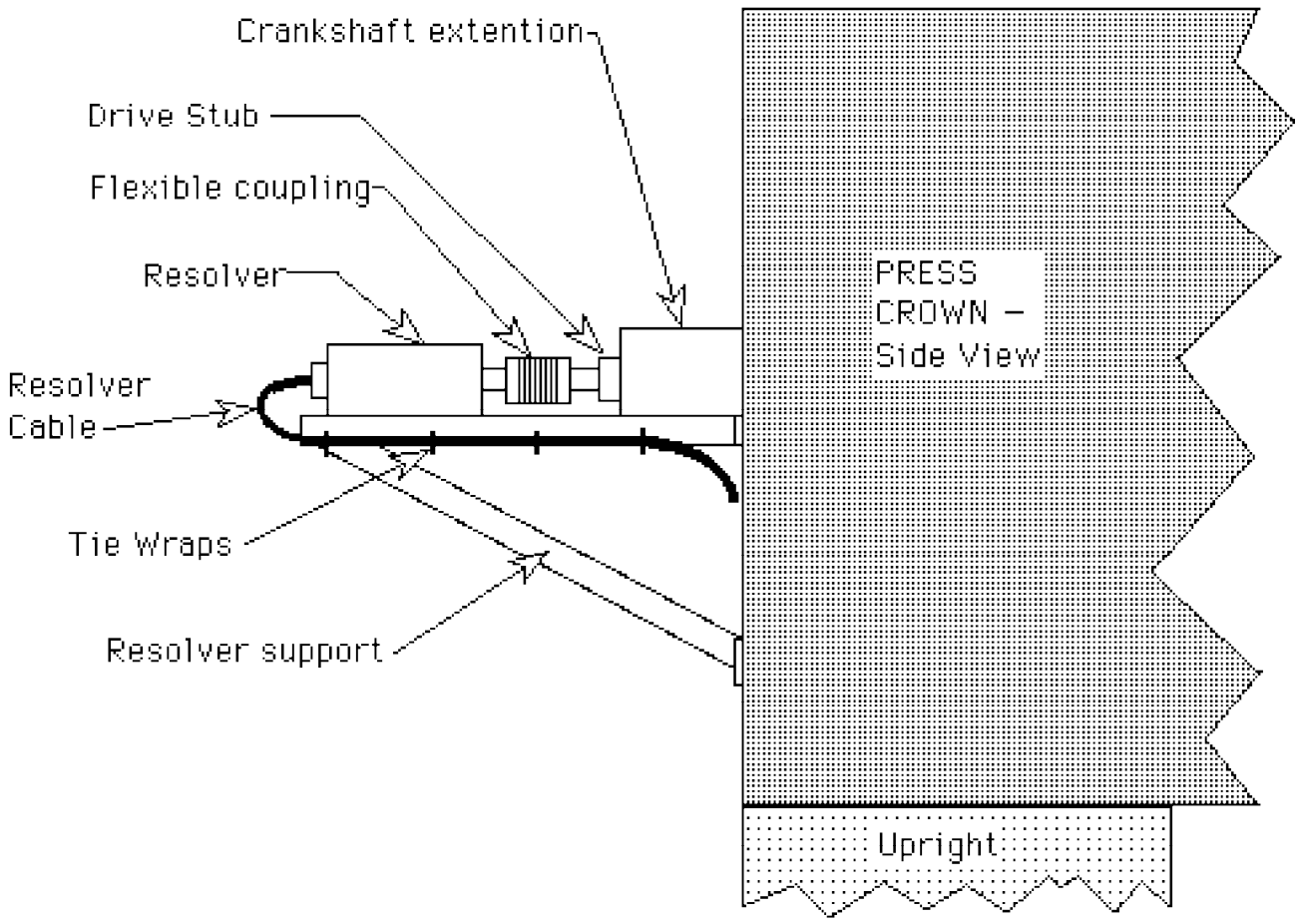

Figure # 2 - Side view - Resolver end drive

Design considerations for end-driving the resolver:

1) Be careful of the end float of the crankshaft. In older presses, 1/8" or more of end float isn't uncommon. If you are using a helical coupling, you can only absorb about 1/16 - 3/32" inch of end play, and when the clearances close, the crankshaft will attempt to push the resolver shaft out the back of the resolver. We have seen several cases where this actually has happened. Needless to say, the crankshaft always wins.

   In cases where excessive end float exists, the "RENBRANDT" type of multiple plate coupling, possibly used in pairs can provide more clearance.

   On the other hand, if you have got a lot of end float, maybe more than 1/4" then DON"T end drive the resolver, use a Timing Belt drive instead.

2) Be careful of "oil-canning" in the mount surface. We don't recommend attaching the resolver mount tripod to a sheet metal end cover, as would be installed over a drive gear. Excessive horizontal motion of the mounting surface will cause bearing problems and broken couplings. Use a Timing Belt drive instead.

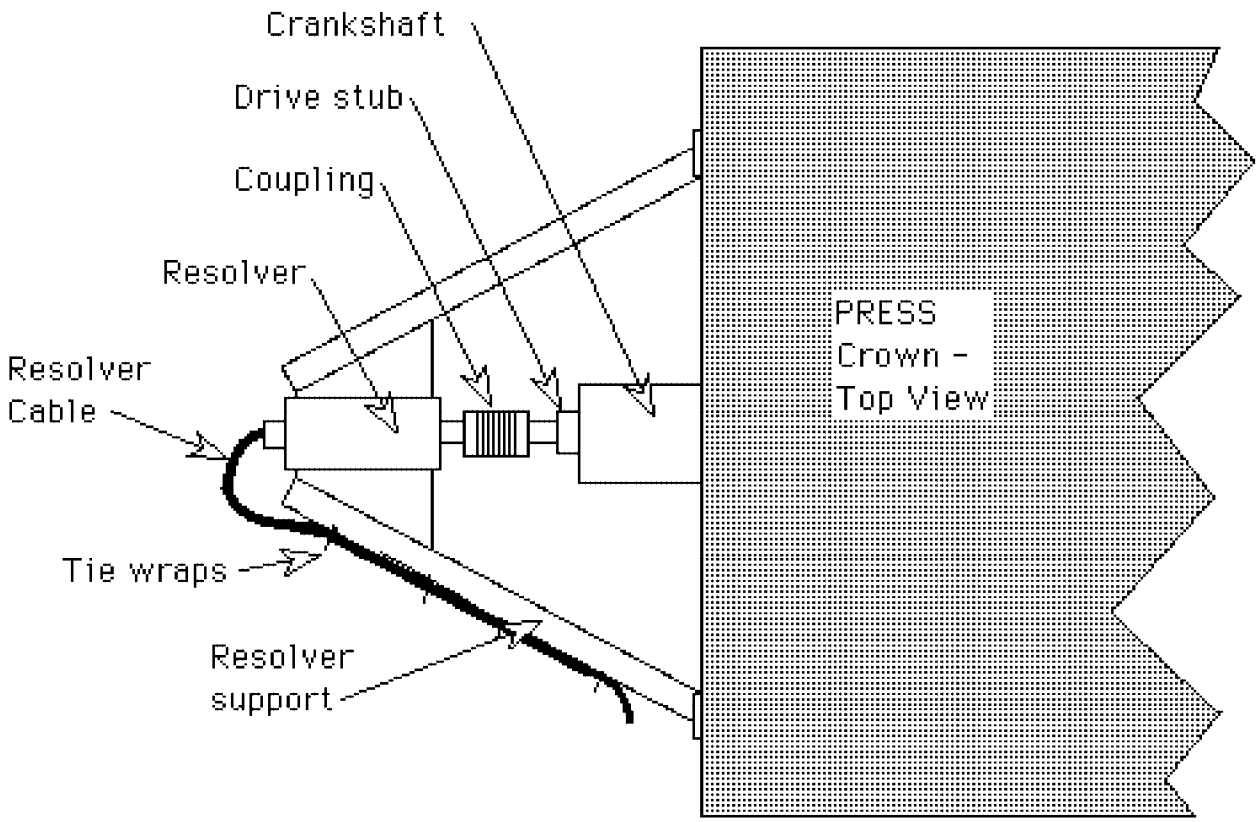

Figure # 3 - Top view - Resolver end drive

3) Make sure you tie the cable down to the support members as close to the connector on the resolver as possible to eliminate swing. Any motion between the cable and the connector will result eventually in a broken cable. The strain relief on the connector is help, but won't do the job alone. The cable must be tie-wrapped to the support structure.

4) Watch out for excessive vibration at the resolver mounting position. If the press really "hammers" it is possible to cushion the shock be installing Pads of "FABREEKA" or similar material between the tripod legs and the press. The idea is not to overly cushion the resolver bracket, but merely to eliminate high frequency shock. The type of shock energy that will hurt the resolver normally has a high frequency, but very little amplitude (actual motion). So a relatively stiff isolation technique can eliminate the damaging vibrations without

compromising the angular accuracy of the resolver.

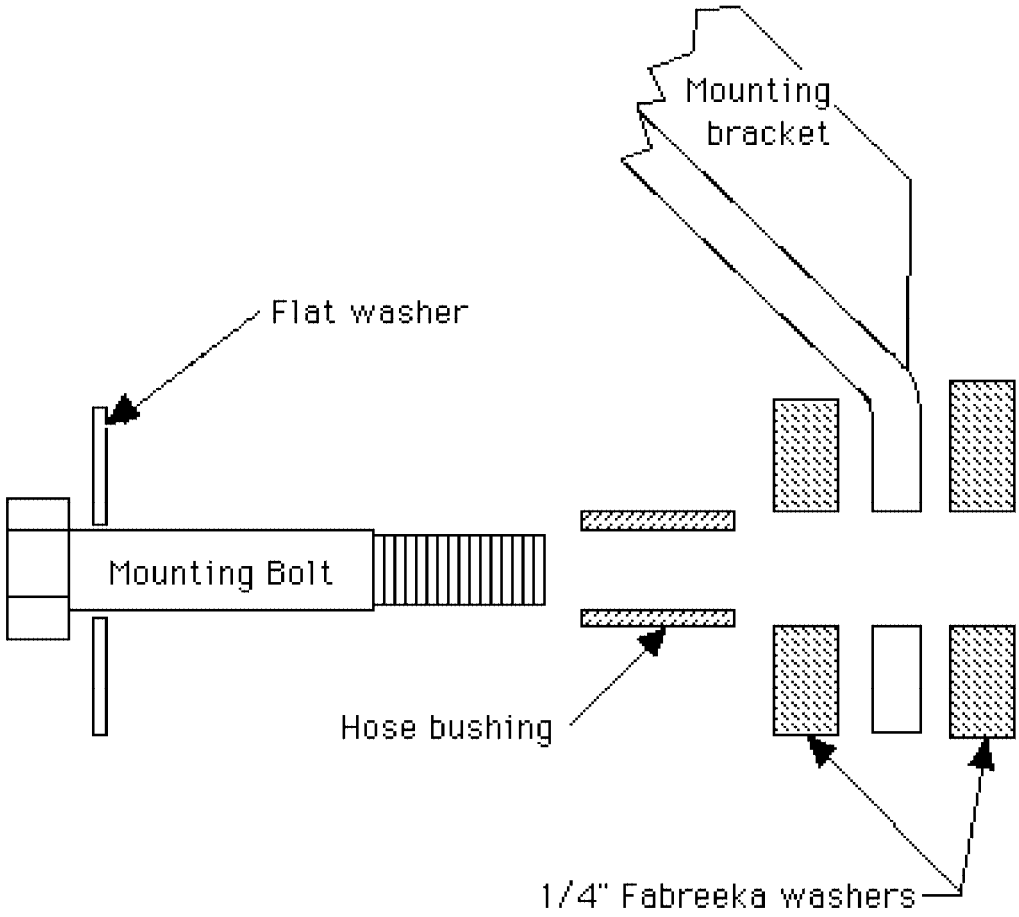

Figure # 4 - Cushion mounts for Resolver bracketry

5) Make sure your mount design allow some means to correct for Parallel Misalignment between the resolver and the crankshaft. If the shafts don't line up, broken couplings will be the inevitable result. Something as simple as shims under the resolver, or slotted holes allowing the pieces of the mount to be adjusted slightly will do the job.

6) The "drive stub" is preferably a machined part that adapts the threaded hole generally found in the end of the crankshaft to a shaft 0.6250" in diameter onto which the drive coupling of the resolver can slip. In case there is not a threaded hole available, a drive flange can be used as shown in the illustration on the next page.

   Note that the drive flange has a Guide rim that accurately centers the flange on the crankshaft. This configuration should be used wherever possible.

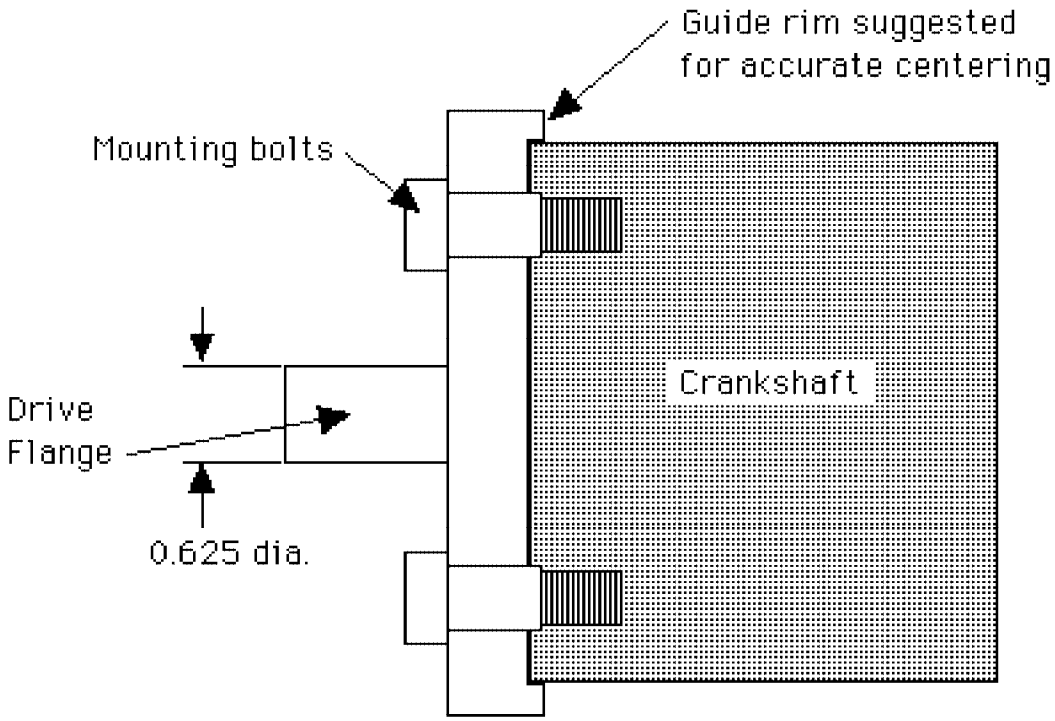

Figure # 5 - Drive flange arrangement

Auxiliary Drive resolver mounting:

In some cases, an auxiliary drive may be mounted to the end of the crank with an exposed end that can be used to support a drive flange. In these cases, a simple bracket can be used to support the resolver directly to the auxiliary drive housing.

The same concerns as above about end float apply here also.

See Fig. #5 below for general arrangement.

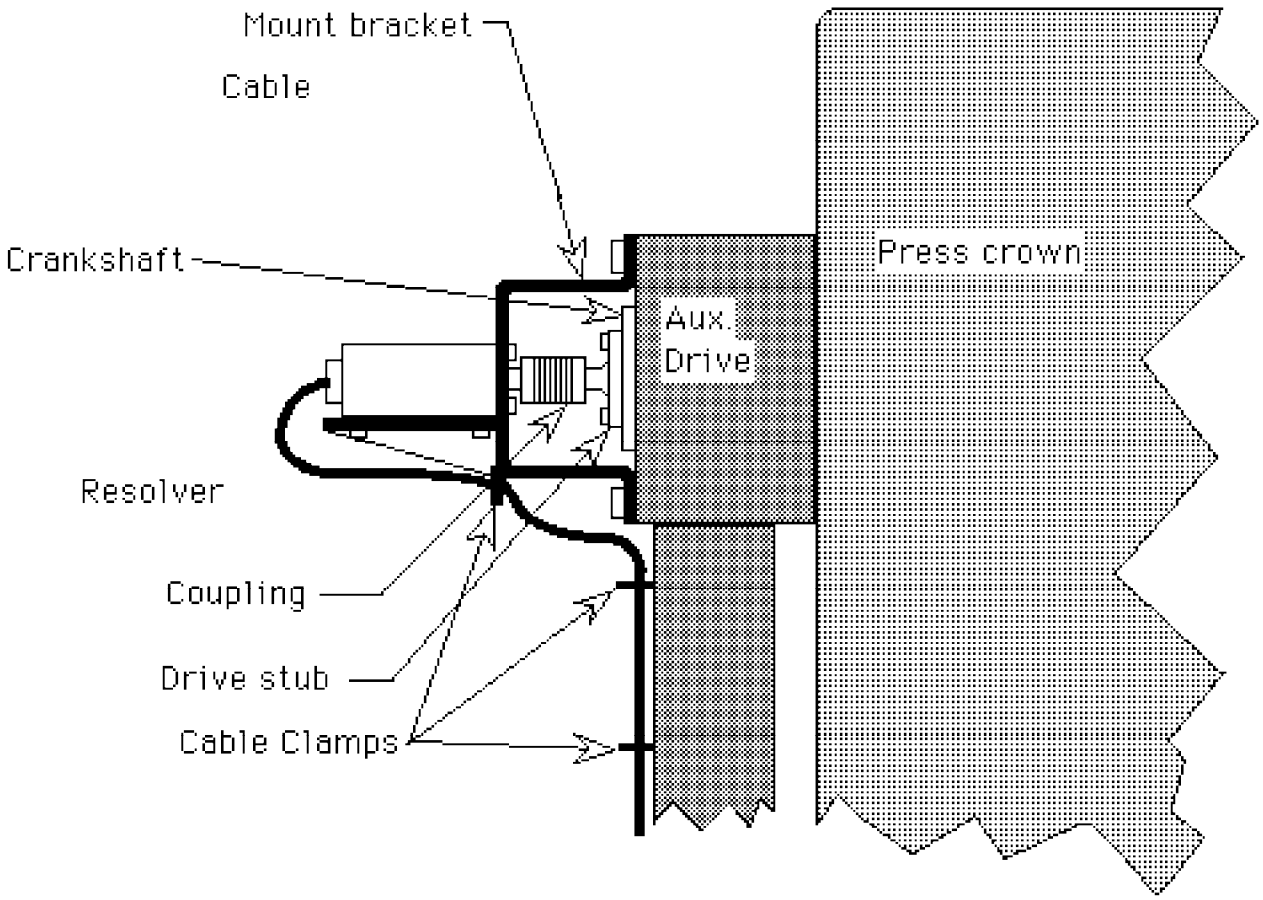

Figure # 6 - Auxiliary drive resolver mounting

Driving the Resolver with a Timing Belt:

In cases where the end of the crankshaft is not free, or there is no easily accessible rigid mounting surface for the resolver bracket, then the alternative is to use Timing Belt drive as illustrated below:

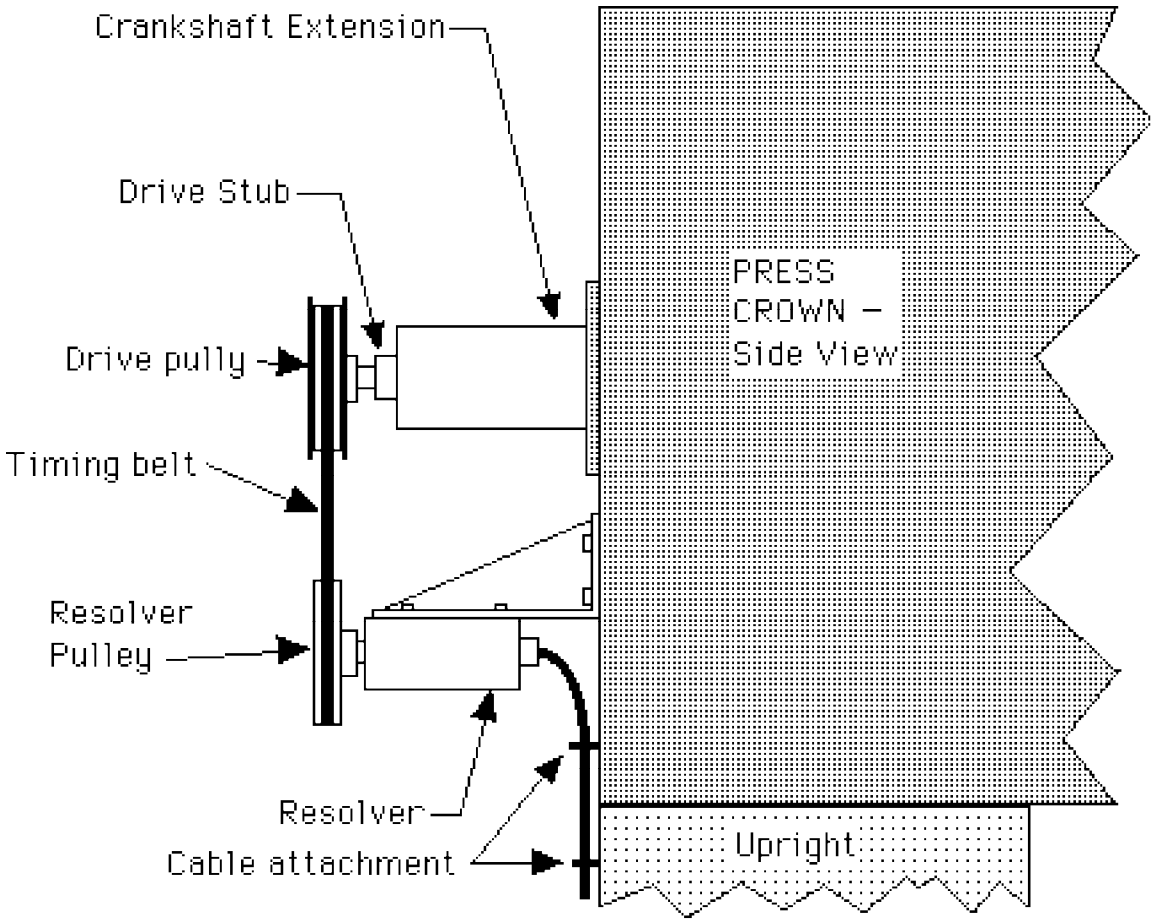

Figure # 7 - General arrangement for a Timing Belt resolver drive

Design considerations for Timing Belt driving the resolver:

1) Use ONLY fine pitch Timing Belts. The Type “L" (0.375 pitch) belts are preferred for most industrial applications. If space is a consideration, then Type "XL" (0.200 pitch) belts are fine.

   Larger pitch belts get progressively more "sloppy" in terms of their angular accuracy.

2) Use LARGE diameter pulleys. The large pulley diameter minimizes inaccuracies due to tooth clearance. We recommend at least 4” P.D. in the “L” (0.375 pitch) type belt.

3) Use double flanges **only** on the DRIVE pulley.

We **don't** use flanges on the resolver pulley to avoid the weight. Since there is a lot of shock and vibration in any press installation, Weight on the resolver shaft translates to bearing load, even without the belt tension. See Fig. #8 below.

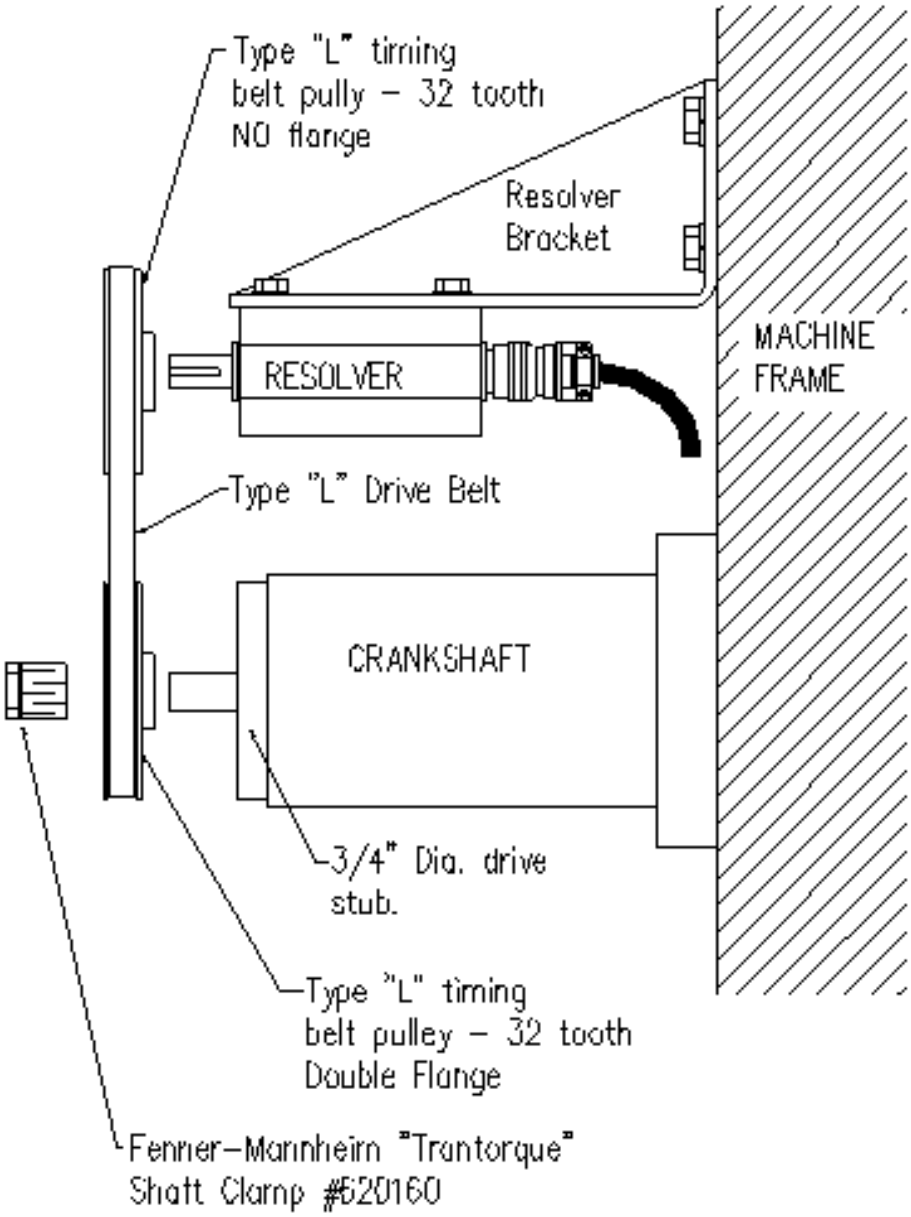

Figure # 8 - Gear belt drive detail

4) We have found the TRANTORQUE™ device from FENNER-MANNHEIM to be a good way to affix the drive pulley onto the crankshaft drive stub. Since there is a lot of shock at the end of the crankshaft, setscrews don't hold terribly well, even if the shaft is flatted. The Trantorque™ device is a double expanding device that seems impervious to vibration. See Fig. #8 above.

5) If the end of the crankshaft is not clear, you can use split pulleys, although they will have to be specially made to order.

6) If the drive is taken from the crankshaft end, make sure that the drive-stub runs concentrically with the crankshaft. If there is any problem with lack of concentricity due to inaccuracies in the crankshaft end threading, or hole location, use a drive flange as in Fig. #5 above.

7) Make sure you include adjustment capability for the resolver so that you can tighten the drive belt when need be.

   The drive belt should be as tight as allowed for the belt size you are using. See the manufacturer's data for guidance. The Resolver shaft is rated 400 pounds radial load, so you don't have to worry about over-stressing the bearings there.

   NOTE: Watch out for radial motion of the crankshaft in older presses that would cause excessive tightness or looseness in the belt at certain rotational positions as the crankshaft moves around in its bearings. Yes, I know that you'd never let your press get that loose, but check it anyway.

Required information for Resolver mount design:

If you are planning to submit information to Signature Technologies Inc. so that we can assist you in the design of your resolver mounting, make sure to include the following:

1) The brand, model designation, and SERIAL NUMBER of the machine.

2) Quantitative measurements of the features in the area where you believe the resolver should be mounted. It's not enough to say, "there's a junction box about a foot from the crankshaft, and slightly above it".

3) An actual measurement (to within 1/32") of the end float, and radial motion of the crankshaft.

4) An actual measurement of any oil canning, or flexing motion of the surface on which you want t mount the Resolver bracketry.

5) If you are going to use a drive stub from the end of the crankshaft, give details of the shaft end including location and dimensions of holes, keyways, and other features. If the shaft is center drilled and tapped, give size and thread specifications of the center hole.

6) If possible, a photograph of the mounting area would be helpful.

7) Include at least a sketch along the lines of Fig. #9 below

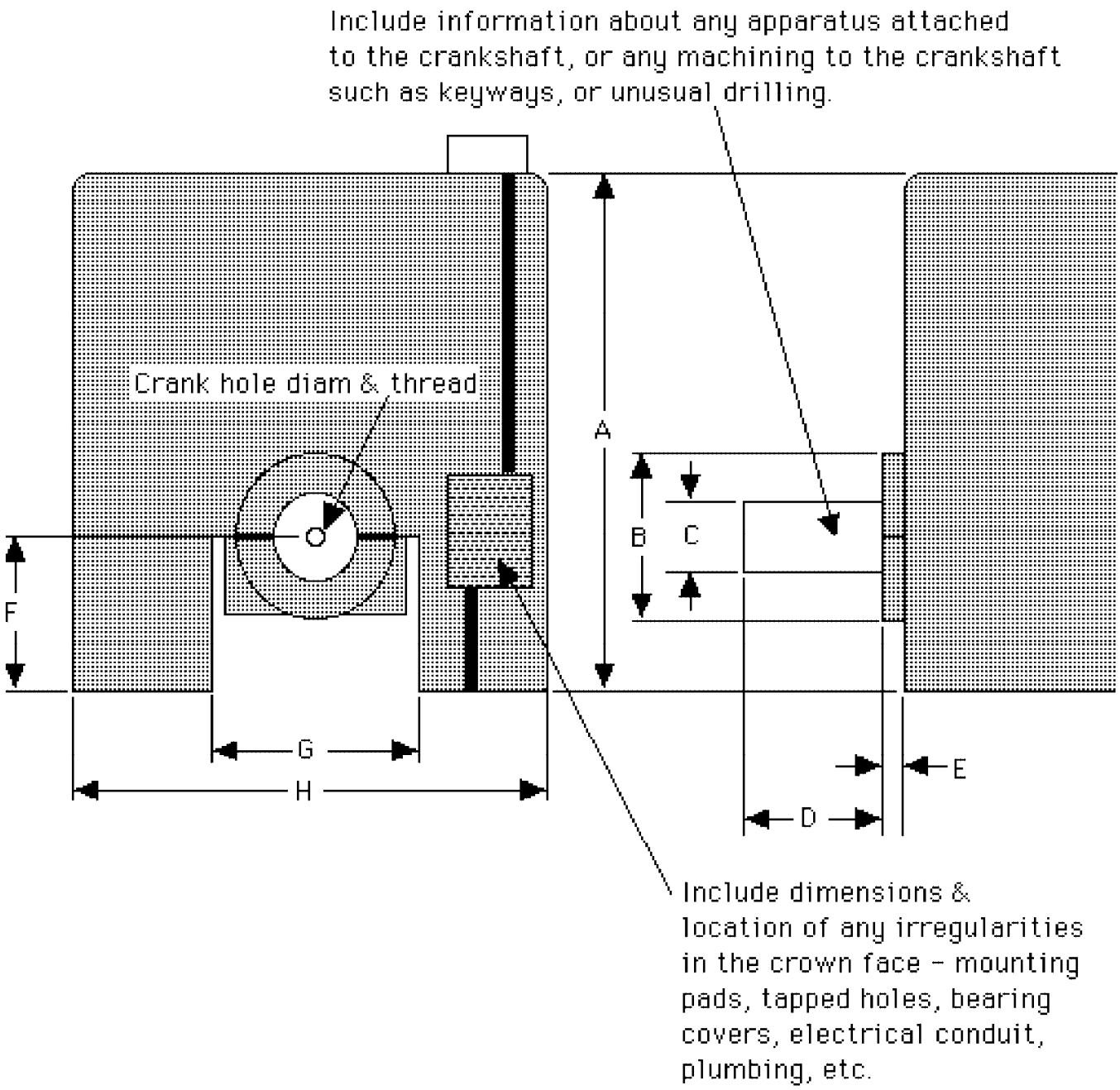

Figure # 9 - Resolver mounting area dimension sketch

FOR LINEAR APPLICATIONS:

Sometimes the use of rotary resolvers is clearly impossible since nothing directly related to machine motion turns. Hydraulic machines are a prime example of this. The only means of commutating data must come from the hydraulic ram itself.

What type of position sensor to use:

You must carefully appraise the shock and vibration of the application. If your machine is smooth running as in a Sheet Molding Compound application, then a glass scale linear encoder is a good choice.

If, on the other hand, you are blasting 4" holes through .250 inch stainless steel, your only practical choice due to the extreme shock will be an Inductosyn linear resolver.

Some linear encoders have a problem in that they are not "real-time". The output doesn't come directly from the code bar like it does with a glass-scale optical encoder. It is generated instead by internal electronics, and updates at a rate controlled by the electronics, not the motion of the ram. Make sure the data conversion/update rate of the device you're considering is at least 10 kHz.

The Magnetostrictive type of linear encoder like the "Temposonic" by MTS, or the Balluff device are not useable on any but the slowest, smoothest applications since they don't update their position data rapidly enough (about 1 kHz or less) to give us the sampling rates we need.

How to couple the position sensor to the slide:

For accuracy, the linear position sensor should be driven as close to the center of the ram as possible.

This consideration is especially important with column-guided hydraulic presses since parallelism control with this design is always pretty poor. The ram will "dance" a lot from corner to corner with variable die loading. If the encoder is attached to the slide out at the column guide area, the wobbling will force sampling to be done erratically, giving uncertain positional data. The other problem is that the "wobble" in column guided slides can be pretty high in frequency, causing high accelerations at the encoder which can destroy it.

On the other hand, the center of the slide moves in a more constant fashion. Ideally, the encoder could possibly be driven by a connection very close to the cylinder drive point on the slide or possibly from double shaft extension on the cylinder itself.

We have gotten acceptable results, however, on gibbed hydraulic machines by coupling the position sensor drive to the outside of the slide structure. If the gib length is long compared to the width of the slide (like the Minster/Tranemo presses) the wobbling tendency is eliminated.

We generally use a tie-rod driven guided encoder design (Like the SONY Magnescale™) as illustrated below. This approach allows us to guarantee the control of the encoder without taking a chance on the accuracy of the press guiding system. If you are certain of the accuracy of your press slide guiding, it might be possible to drive the encoder directly from the slide if geometry permits.

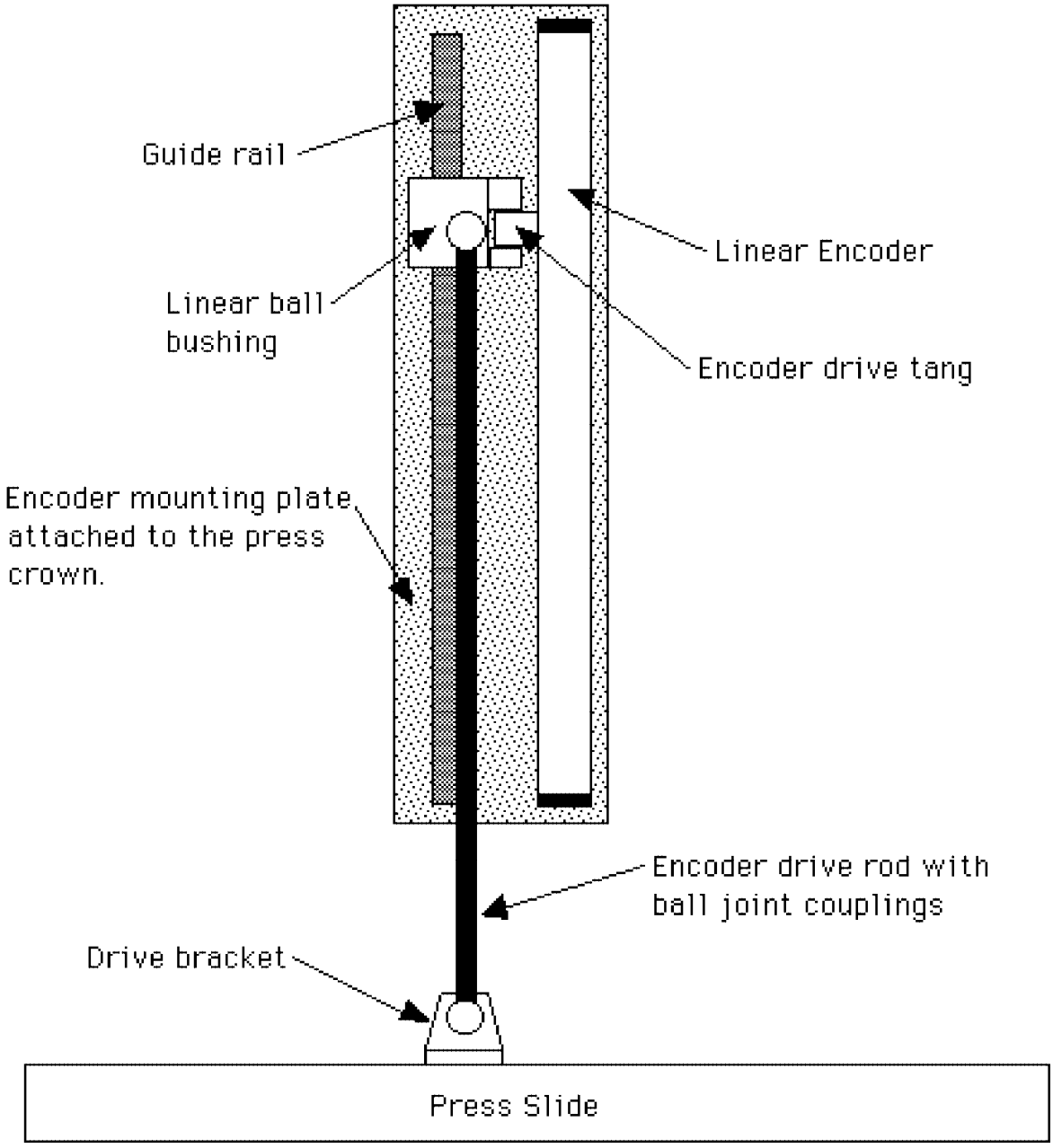

Figure # 10 - Linear encoder arrangement

For really rugged linear encoding the Inductosyn™ device by Farrand can't be beat. We arrange the Inductosyn components on a sub-plate with precision guiding, and connect it to the machine via the same tie rod as the optical encoders. Optionally on large gibbed machines, the Inductosyn components could be integrated into the upright structure, using the press gibbing for guidance.

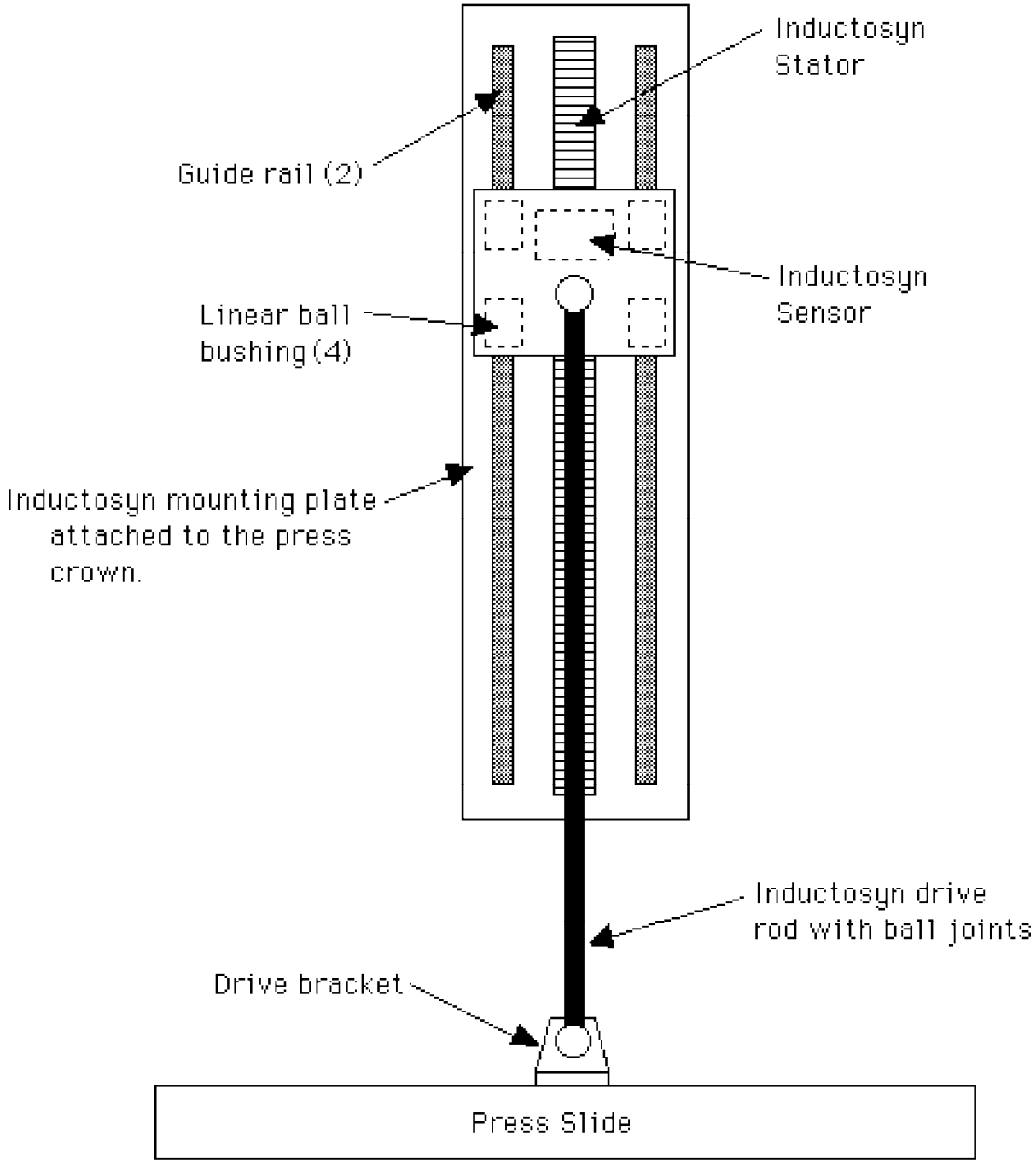

Figure # 11 - Typical Inductosyn™ installation

Signature Technologies Inc. can give guidance on linear applications, which generally require a high degree of integration into the existing press structure. In general, due to the sensitive nature of these applications, we would prefer to work in a close relationship with the customer. We provide a complete engineering package that the customer can opt to manufacture on his own. We then perform the position sensor sub-system assembly and adjustment, as well as supervising and tuning the press installation.

Installation assistance:

As stated above, Signature Technologies Inc. stands ready to assist you with your installation.

We will assist by phone in any area that you want to discuss, and have a variety of technical publications addressing various topics that have come up in the course of installing the SignatureACE™ or SmartSAM™ systems in the field.

If engineering is needed, we can provide it to any level you want. Call us with details of your requirement, and we will respond with a quote for services.

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