

More on Three-phase Converters

by Robert J. Matthys

Steve Acker's article on three-phase converters ("A Simple Phase Converter," *HSM*, January/February 1991) contained much useful information, but there is more to the three-phase converter story. First, you do not have to use a separate three-phase idler motor to run a three-phase motor from a single-phase power line. You can use the three-phase motor on your mill or lathe (or whatever) as the idler motor. This reduces the converter cost considerably, but at the same time restricts the converter to driving just one motor load. If you have two or more three-phase motors to drive (two in my case, a mill and a lathe), then a separate idler motor for the three-phase converter makes sense.

Second, adding two run capacitors to the converter will increase its horsepower, and help balance and equalize the voltage and phasing of the individual phases of the three-phase converter. The converter will work without the run capacitors, but two of the individual phase voltages will be down 15% to 20% without them, and the power capability of the converter is reduced 25%. The run capacitors are separate from the start capacitor, and have about one-seventh the capacitance of the start capacitor. The run capacitors are permanently connected across the two idler motor phases that are not excited by the incoming single-phase power line.

CAPACITORS

The size of the start capacitor varies with the motor size in horsepower. The start capacitor should be about 70 microfarad/HP when using the oil-filled paper-type capacitor. It apparently takes more capacitance with the electrolytic type, as Acker found the start capacitor should be 100 microfarad/HP when using the electrolytic type of start capacitor. In practice, the start capacitor capacitance is not critical. If the start capacitance is half of the above values, the motor just takes longer to come up to speed. If twice the above values, the motor comes up to speed very quickly but with a heavier starting current that may dim your workshop lights for an instant.

What does the start capacitor really do? Well, one-phase and three-phase electric motors will both run on single-phase power, but they won't start on single-phase. They both need at least two-phase excitation to start rotation. A capacitor will shift the phase, and when tied to a second motor winding will provide the two-phase excitation needed for starting the motor. After the motor gets up to speed, the start capacitor can be removed from the circuit, and the one-phase or three-phase motor will continue to run on single-phase power.

The size of the run capacitors also varies with the motor size in horsepower. The two run capacitors should each be about 12 microfarad/HP. The capacitance values may be different for the two phases. The capacitance values are not critical and are determined by trial, adding or subtracting capacitance until the voltage across the two motor phases is equal to the line voltage across the third motor phase.

During the startup of a 220-volt converter, the line-to-line voltage on two of the three phases of the idler motor will rise to 330-370v AC. This means that both the start and run capacitors must be rated at 330-370v AC (or greater) for a 220v converter.

The oil-filled paper-type makes the best start capacitor. It has an essentially unlimited life, and comes in an oval-shaped metal can. However, it takes a bank of three to nine of them (depending on their capacitance) tied in parallel to get enough capacitance for motor starting purposes. This is due to the limited capacitance available in a single capacitor. Used oil-filled paper capacitors are available at electronic surplus stores for \$2 to \$10 each, depending on size.

Because the start capacitor is used only during the motor startup, the cheaper (and lower quality) non-polarized aluminum electrolytic type can also be used as a start capacitor. Unfortunately, electrolytic capacitors have a limited life, because their internal chemicals evaporate over time. They must be periodically replaced (every four to ten years or so). They

also have high internal resistance losses, which cause high internal heating in AC voltage applications, and which pretty much limits their AC use to intermittent duty things such as motor starting.

The run capacitors **MUST** be the oil-filled paper type, as the electrolytic type will not stand up to continuous AC duty.

Do not buy old or surplus electrolytic starting capacitors, as there may be little capacitance left in them due to chemical evaporation over time (old oil-filled paper capacitors are okay). Electrolytic capacitors can be identified by their round, black plastic cases. New electrolytic capacitors cost \$10 to \$15 at motor supply stores.

RELAYS

It takes two relays to operate the converter. One relay connects the start capacitor to the idler motor during startup, and is operated by pushing the momentary "START" button. The second relay applies the incoming 220v single-phase power to the idler motor. This relay has an extra lock-up contact to keep the relay closed (and keep the 220v coming to the motor) after the momentary START button is released..

Relays are rated in terms of the maximum contact current and motor power they can safely handle. The 25 amp (1-3 hp) and 30 amp (1-4 hp) sizes are the ones to use. Unused and slightly used relays are available at \$5 to \$10 each from electronic surplus stores and used motor outlets.

MOTORS

If you use your three-phase load motor as the idler motor, then its characteristics are already fixed. If a separate idler motor is used, it should be somewhat bigger than the load motor, as the idler motor does not operate efficiently and it must also carry the electrical losses in the load motor, which are not

included in its horsepower rating. Steve Acker uses a two-times bigger ratio for idler motor horsepower to load motor horsepower, which is fine, but a one-and-a-half times ratio will also work. As usual, nothing too critical.

A new 1-3 hp motor will cost \$100 to \$300. Three-phase motors are the simplest and most reliable of any motor type, and they last a very long time. Consequently, there are lots of used three-phase motors available at \$25 to \$50. If the motor you buy has been used a lot, its shaft bearings may have gotten noisy, and you may want to replace them to reduce the noise level if it's to be located inside your shop.

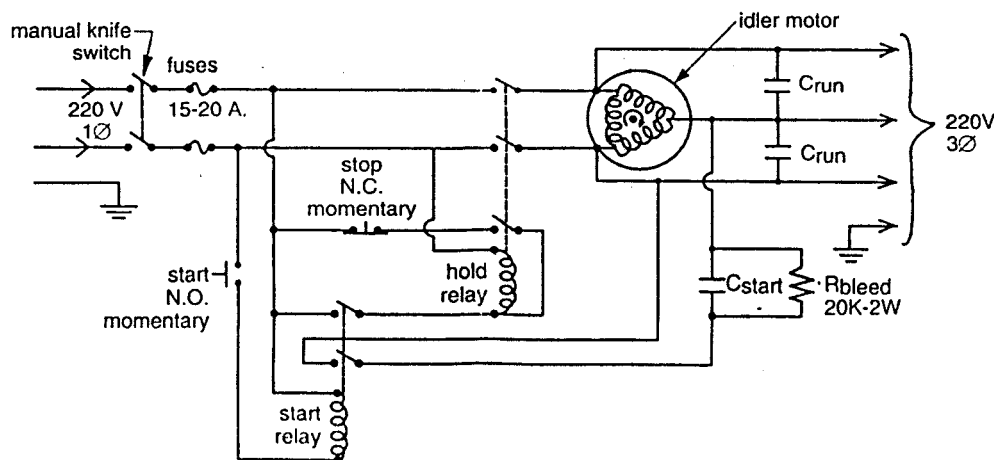
CONVERTER CIRCUIT

Refer to the schematic of a typical converter circuit, showing the two relays, the idler motor, and the start and run capacitors. The idler motor shown can be either a separate three-phase motor or the actual three-phase motor you want to drive. The schematic also shows a momentary "STOP" switch, that opens the lock-up contact on the second relay and makes the relay drop out, disconnecting the 220v single-phase power into the idler motor. The relay coil connections are for 220v AC coils. 110v AC coils can be used instead by reconnecting the relay coils across the 110v line.

The momentary START and STOP switches are commonly sold as a pair in a small metal box (\$5 used, \$15 new), so they can be put in a convenient location for the operator. They usually have one normally open contact on the START button, and one normally closed contact on the STOP button, just as is shown in the schematic. Other contact arrangements can be had, but are not as widely available.

SAFETY

After starting the idler motor, the start capacitor retains an electric charge of up to 500v DC. If the start capacitor is the electrolytic type, the



charge will bleed down to zero volts in a short while through internal leakage. If the start capacitor is the oil-filled paper type, the 500v DC charge will take a very long time to bleed off because the internal leakage of the capacitor is extremely low. So, for safety reasons, an external bleed resistor is placed across the oil-filled paper-type start capacitor. A 20,000-to-100,000 ohm two-watt resistor will do the job nicely. The run capacitors do not need bleed resistors as they are shunted by the idler motor windings which will bleed the run capacitors down to zero volts.

Also for safety reasons, all of the electrical components should be enclosed in a *grounded* metal box. Ground the motor frames, too. Use heavy connecting wires (No. 12), and fuse both sides of the 220v line. Safety first. Remember that 220v is more than enough to kill you if you make a serious mistake.

ELECTRICAL SCHEMATIC OF ONE-PHASE TO THREE-PHASE CONVERTER

R_{BLEED} is Not Needed if C_{START} is electrolytic type.

C_{START}= 70-100 Mfd/HP, C_{RUN}= 12 Mfd/HP

NEW LIFE VIDEO PRODUCTIONS



presents...

Instructional Videotapes

For the Machinist
by Rudy Kouhoupt

FUNDAMENTALS OF MILLING MACHINE OPERATION

Rudy presents the basics of milling, and a practice project to help you learn. Dimensioned drawings are provided. (2 hours)
ONLY \$52.95 POSTPAID

FUNDAMENTALS OF MACHINE LATHE OPERATION

The basics of lathe operation - boring, facing, and turning - are covered in detail. Included are plans for a boring tool you can use. Dimensioned drawings are provided. (60 minutes)
ONLY \$42.95 POSTPAID

BUILDING A STIRLING HOT AIR ENGINE

Rudy describes his design for a fast, free-running Stirling engine that offers some machining challenges and hours and hours of fun. Dimensioned drawings and outline provided. (3 hr., 22 minutes)
ONLY \$62.95 POSTPAID

BUILDING A SMALL STEAM ENGINE

Using just a Sherline lathe and mill, Rudy takes you through the fabrication of a handsome little horizontal engine that goes like the wind. Dimensioned drawings and outline provided. (3 hr., 40 minutes) ONLY \$62.95 POSTPAID

HOW TO CUT SCREW THREADS

Various thread forms, thread parts, cutting calculations, and techniques for cutting on the lathe are described. Printed charts and tables are included. (62 minutes) ONLY \$37.95 POSTPAID

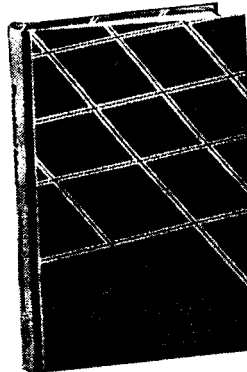
HOW TO CUT SPUR GEARS

Using just a small mill and your lathe, you can learn how to cut your own spur gears. Terminology and techniques are thoroughly covered. Printed charts and tables are included. (43 minutes)
ONLY \$37.95 POSTPAID

VISA AND MASTERCARD ACCEPTED

New Life Video Productions

P.O. Box 175, Traverse City, Michigan 49685 • FAX (616) 276-7194



Get Your Copy
Today!

only \$34.00

While Supplies
Last

Practical Ideas ...

By The Editors of
American Machinist
Magazine

- *Practical Ideas* is the Book for Students, Home Hobbyist & Professional Machinist alike.
- *Practical Ideas* is a collection of over 520 money making and time saving set-ups regarding all phases of Metal Working, Tooling and Maintenance Machine Shops.
- *Practical Ideas* is a trouble shooting guide to problems in Drilling, Tapping, Turning, Threading, Milling, Boring, Grinding and more.

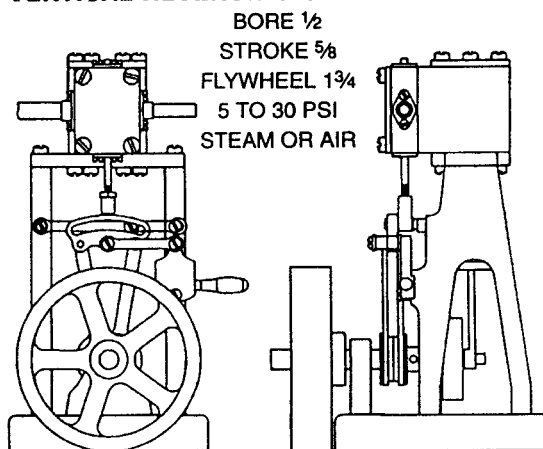
Hard Bound 333 pgs.

Send money order or check for only \$34.00 to:

EM&S E. 3109 Olympic, Suite 107 • Spokane, WA 99207

WA Res. add 8% Sales Tax. \$5 Shipping & Handling Outside Continental U.S.

VERTICAL REVERSING STEAM ENGINE KIT



BORE 1/2
STROKE 5/8
FLYWHEEL 1 1/4
5 TO 30 PSI
STEAM OR AIR

Completely machined. Only hand tools required for assembly.

MODEL VR1A \$106

Price includes shipping anywhere in USA

Other models available starting at \$22.

Send for Free brochure.

GRAHAM ENTERPRISES

P.O. BOX 15230

RIO RANCHO, NM 87174-0230

