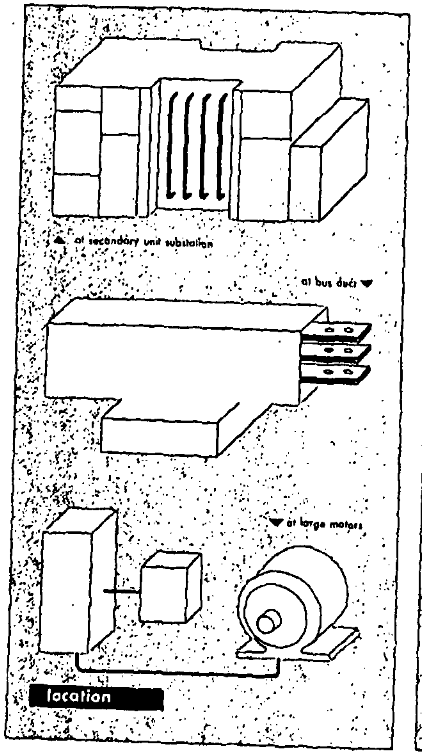
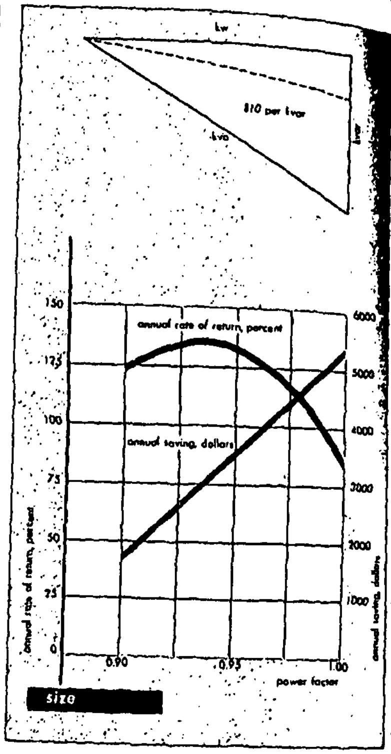




Today's power engineers are well aware of the advantages of high power factor (POWER, July 1953, pp 84, 85). They weigh carefully the pros and cons of using synchronous motors instead of capacitors, to raise pf and get an efficient motor to boot. So, skipping theory and benefits of pf improvement, let's tackle question of locating and sizing capacitors.

Three locations used widely are: (1) at secondary unit substations (2) on secondary bus duct (3) right at motor load. Trick is to put them where they do most per dollar invested.

Locating right at motors generally means greatest investment but usually does best job. You can eliminate switching, since capacitors are connected and disconnected with motors. This proves an excellent location provided motors are large and operate quite steadily. When motors aren't operating, the capacitors represent a substantial idle investment.

If your main aim is to cut utility charges by improving pf, a central location near incoming lines is the best bet. This generally costs less, but you lose some plus values—increased plant feeder capacity, reduced power losses.

Where induction motor loads are small, or where large motors operate intermittently, secondary unit substations are becoming a common spot for locating a capacitor bank.

The practical way to determine capacitor size is by calculating rate of return and actual dollar savings for various final pf's in your plant. Sketch above shows typical form.

What's limit? When incremental saving for each capacitor kvar added fails to be economically attractive. It's rate of return on capacitor investment that's important, but final pf isn't limited to point corresponding to maximum rate of return. It may be worthwhile to go beyond this point, even though rate of return is less, if additional system capacity is released. Rate of return is often greater for small plants because their loads won't justify the best utility rates.

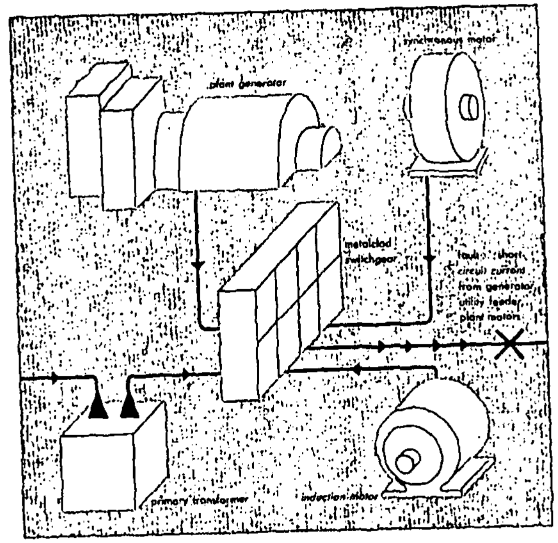
Developing harmonics as a result of a sizeable capacitor installation is still a matter of concern, generally unjustified, to some engineers. Theoretical calculations reveal possibilities of harmonics and resonance, but if plant voltage is approximately normal, it's practically impossible to overload a capacitor by harmonics. Remember, capacitors don't generate harmonics: sources are transformer magnetizing current, rectifiers, arc furnaces, generators.

Manual switching of capacitors is adequate in most plants. Where kvar of capacitors is greater than two-thirds of the transformer rating, figure on automatic switching.

Larger utilities, heavier interconnections, larger plant generators, bigger motors—all mean that when a short occurs vastly greater currents flow into it. In existing plants as well as new ones, circuit protective devices thus need much more interrupting capacity. Lack of it could easily cause a plant shutdown. Two steps will keep you out of such trouble: (1) Know available short-circuit currents in your plant. (2) Be sure breakers will handle them.

Start by getting the incoming figure from your utility. From there on, steps in determining available short-circuit currents at any point on your distribution system have been boiled down to simple arithmetic. Check with your equipment manufacturer—several have developed simplified methods of short-circuit calculation.

In selecting interruption equipment, be sure to allow for tomorrow's needs as well as today's.

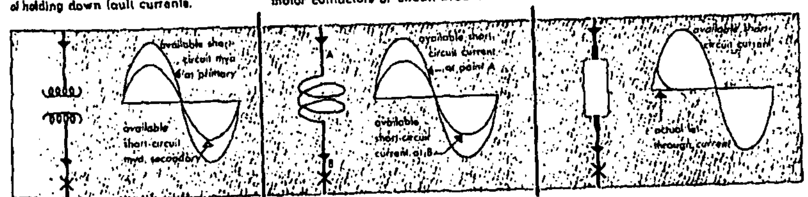


Adequate circuit-breaker interrupting capacity takes first place

transformers Include transformer impedance in short-circuit calculations but don't specify higher than standard as it may lead to voltage regulation trouble. Consider using several smaller transformers in primary sub and splitting secondary bus as one means of holding down fault currents.

reactors Designed to limit short-circuit currents, reactors have been used for years in generator leads and bus ties. Now some makers of motor starters supply built-in reactors to hold available short-circuit currents to values that can be safely handled by motor contactors or circuit breakers.

fuses Properly applied, high-interrupting-capacity fuses chop short-circuit current off in first quarter cycle, before maximum is reached. Transformers and reactors modulate current values; fuses, like circuit breakers, interrupt it. But circuit breakers often allow several cycles before opening.



But consider other circuit components that limit value of short-circuit currents

Before jumping to reactors to cut available short-circuit currents, consider how they'll affect over-all plant operation. For instance, on main feeder bus, they must be sized to limit current values in all branches off it, may seriously affect voltage regulation. And a fault on any branch circuit pulls voltage down equally on all other branches, may cause the under-voltage releases to kick out.

Power engineers now like to put reactors in branch circuits, protecting a group of small breakers. Each is independent and reactor is unaffected by added loads on main bus. Four impedance values meet most low-voltage needs in secondary circuits: 0.010, 0.015, 0.020, 0.025 ohms. Each is available to cover a range of fault currents. Since control centers provide for a 800-amp bus, maximum-continuous-current rating of reactors for them need not be more.

Look at voltage regulation again before applying reactors: How much will voltage change from light to full load? How far will it dip during motor starting? Would larger breakers be better?