remedy is, probably, to take the control out of the hands of operators and predetermine acceleration, speed, torque and current through magnetic switches. This means, however, extra complication and expense, but will in the end pay for itself.

In regard to working efficiency of electric cranes, wherever a great amount of material has to be handled the general rule of keeping material always **going in same** direction should be adhered to as much as possible. It is very inefficient and costly to handle small loads at very high speeds over long distances on large and heavy cranes. In deciding on the speed of different motions we should not lose sight of the fact that the normal load hardly ever exceeds one-fourth maximum load and speed should rather be made to suit normal load; work in foot-pounds should then be made the same for the maximum load. Series direct-current motors are better adapted to this than alternating-current motors and will give, for this reason, a better working efficiency.

The proper type of girders should be selected for the work to be done by cranes. Heavy double or single-leg gantries should not be used where fast and continuous bridge work is required. It does not matter whether box lattice, single-web, or rolled-beam section is employed for girders; all will give equal satisfaction if properly designed. It is erroneous to think that lattice girders on outdoor cranes are not so susceptible to wind pressure; experience has proven that the four rows of angle braces of girders cause as much resistance as plated girders of same capacity. The fish-belly girder allows material to be used to best advantage; the square lattice girder, however, is easier fabricated, as all sections at different points are alike; it makes a rigid and stiff construction, if properly braced, with the least dead weight.

Gears, bearings and shafting may be regarded as the most important parts of cranes. On their proper design depends largely the efficiency, safety and cost of maintenance of cranes. Wherever possible, worm, bevel, split and overhanging gears should be avoided. All gears should be of steel, with standard involute-cut teeth; all high-speed gears should be made of high carbon steel properly tempered and to run in oil-bath. No pinions with less than 13 teeth should be used, as they will run rough and are liable to be mechanically weak.

Although only one-half maximum load can come ordinarily on one tooth, for the sake of longer life and safety each tooth should be made amply strong to stand entire maximum load. As all gears on cranes are worked in either direction and continuously reversed, teeth should be made so strong that they will resist absolutely all bending stresses; otherwise crystallization and breaking of teeth would be the final result. One cannot recommend too strongly to run all gears, wherever possible, in oil-bath; the resultant noiseless and easy running of the crane, as well as better efficiency and lower cost of upkeep, would soon pay for it.

All brackets and bearing supports should be made strong enough to avoid deflection of shafts and their binding in bearings. Where, on account of the light weight, it is impossible to prevent working and twisting of bearings, they should be made of swivelling type and be self-aligning.

The use of roller or ball bearings on cranes for mill work cannot be recommended, and should only be allowed where, on account of hand power, friction must be reduced to a minimum.

It is surprising that more use is not made by crane builders of oil-ring bearings similar to those on motors. Cranes equipped throughout with such bearings are always ready for work, much cleaner, do not drop oil on men and objects below, run easier and quieter, with less power consumption and cost of maintenance.

Cranes are generally handled much rougher than any stationary machinery and require continuous attention. They are naturally located in very inaccessible places, often high up, very hot, and dirty and smoky. Proper means should always be provided to give easy access to them without necessitating climbing of ladders or building columns; good stairways with railing, platforms and galleries on top for necessary inspection and repairs should always be furnished with crane structure. Crane girders should always have walks all around girder, and, if possible, trolley, to prevent slipping or falling from crane.

The use of over 275-volt currents on cranes cannot be recommended, as accidental touching of conductors is liable to be fatal. Even where electric shock is not dangerous, it may cause serious injury through fall by fright; therefore, bare conductors should be avoided as much as possible or be plainly marked by some bright colors. Means for preventing cranes from running away and wrecking themselves through wind pressure or accidental starting of motors should always be provided.

The proper location and arrangement of operator's cab is of great importance. Over yards, when material is often obstructing clear view, where operator handles material by means of grab buckets or lifting magnets without any assistance below, cab is best mounted direct on trolley. Man trolleys can be operated at higher speeds; manual brakes can easily be provided to control trolley and hoist motion, and crane can be wired easier and cheaper. Locating cab in centre on one side of crane, instead of on end of girder, gives operator often a much better view.

Crane motors are called upon to work mostly under very trying conditions, such as shocks, vibrations, frequent starting, stopping and sudden reversing, high lowering speeds, overloads, and many others, not to mention dirt, heat, rain and, last, but not least, lack of attention.

The ordinary commercial motor has been found unable to withstand continuously such conditions, and special mill-type motors had to be developed by motor builders for this work. Through co-operation with operating men, all weak, defective and undesirable features have been remedied, and there should be no trouble in getting crane motors which will stand operating conditions of mills and at the same time reduce cost of maintenance and repairs to a minimum.

Motor frames are now made entirely of steel and allow easy access and removal of armatures and fields, being split horizontally through field castings and bearings. The spider construction makes it possible to renew shaft or commutator without touching windings. Shafts are made much heavier, with larger keys and taper ends; core is pushed on spider instead of on shaft in such a way that it cannot get loose and damage windings or leads. Ample ventilation with very low core losses is provided; brush-holders have adjustable tension springs, bearings are arranged for oil-ring lubrication. Insulation is almost fire-proof and will stand higher temperatures than on standard motors.

The poor commutation of high-peak current has always been a defect of crane motors, and caused frequent renewal of brushes and commutators. The introduction of interpoles on all crane motors has greatly helped to improve commutation and do away with rough and worn commutators, short-circuiting of bars, and final grounding of motors and burning of controller contacts, as well as blowing of fuses. Sparking and flashing over at brushes even with three times full-load current is not often encountered in interpole motors. The slower speed of these motors allows