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Western Industry

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September 1956 issue

How to be Sure When you're Buying Gears

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Western Industry

ANNUAL PLANT POWER ISSUE

How to be sure when you're buying gears

Do you know how to select exactly the right gears to fit your needs? . . . and how to search out most appropriate gear values? Price and size are not the only factors to consider.

THERE IS HARDLY a skill known to the world which is not covered these days by countless pocket editions of the "How to . . . " series.

"How to Trap a Platypus"
"How to Half Sole a Pair of Snowshoes"
"How to Be Happy Tho' Married"
"How to Barbecue a Hippopotamus"

These are but a few of the sparkling activities whose mysteries may be explored and whose directions may be exploited by simply making a quick trip to the corner drug store.

And now—"How to Select Gears," surely not the most fascinating or the most glamorous of activities, but certainly one of absorbing interest to the design engineer, purchasing agent, plant manager, production superintendent, or any builder or user of gear driven equipment. The success of his business and the performance of his equipment is vitally dependent on buying the finest gears, backed by a reputable gear manufacturer with a vigorous service organization, and at economical prices.

To begin with, it's important that you know about AGMA (the American Gear Manufacturers' Assoc.), a clearing house of knowledge on gears. AGMA is an association of America's leading gear manufacturers, existing for the purpose of establishing standards, ratings, materials, formulae, etc., to provide industry with standard methods of gear size selection. Gear firms' engineers are actively engaged in committee work, striving constantly toward these ends. Obviously, the purpose of this body is to improve gear products, to establish standard rating methods, to protect the gear user from inferior materials, and to assist him in making intelligent selections through the help of its members.

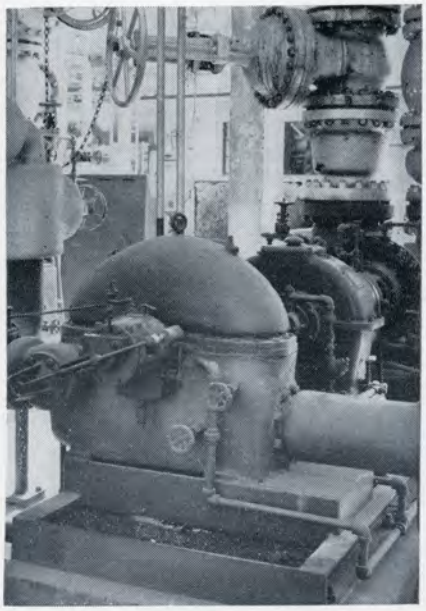
Before going into some typical examples of gear selection by AGMA procedure methods, we should take time out to clarify what AGMA does not do. While it is true that "yardsticks of measurement" are pretty well established, there is no such thing as a "yardstick of value," since AGMA members are under no restrictions on how much added value (plus features) they may build into their reduction gears, gear assemblies, or a single loose gear. AGMA exerts no jurisdiction over member pricing policies. Considerable variation will be found in the construction and design of various gear manufacturers' products, but the AGMA member must conform to specific minimum standards.

A good example of how the buyer must search for and seek out the best value, for instance, would be the selection of a *herringbone, double reduction, parallel shaft gear reducer*. To illustrate the factors involved in mak-

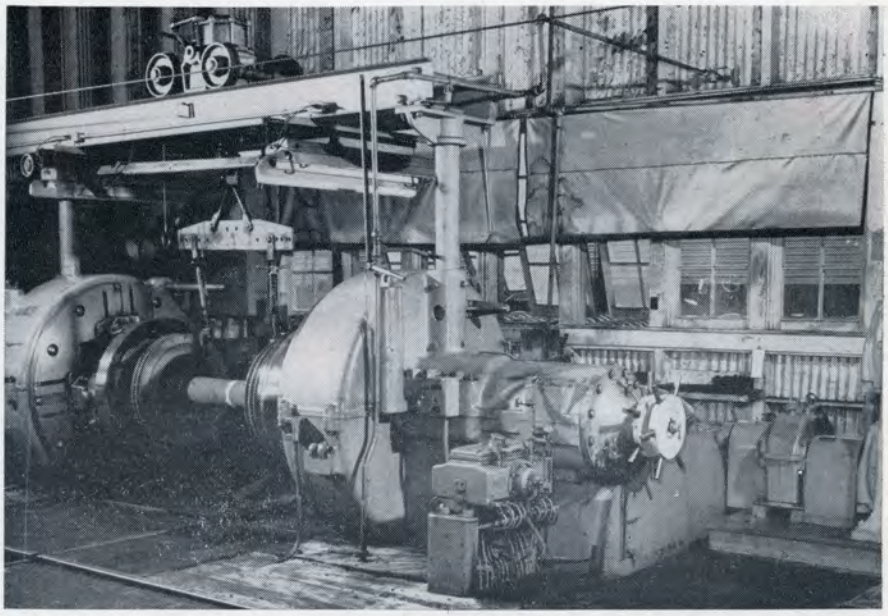
COMPARISON OF 8 LEADING MAKES OF GEAR REDUCERS OF APPROXIMATELY SAME CATALOG HORSEPOWER AND RATIO AT 1,150 RPM. INPUT

Gear Manufacturer	Ratio	Catalog Horsepower	Mainshaft Dia.	Shaft Center Distance	Weight
"A"	28.4	107	6 in.	30 in.	4,590 lb.
"B"	28.7	117	6 in.	30 in.	4,000 lb.
"C"	28.1	112	5 7/8 in.	32 1/2 in.	4,050 lb.
"D"	26.8	115	5 3/4 in.	28 in.	4,000 lb.
"E"	28.6	107	5 1/4 in.	34 1/2 in.	3,500 lb.
"F"	30.0	117	5 1/2 in.	28 in.	3,400 lb.
"G"	27.5	113	5.1875 in.	28 in.	3,100 lb.
"H"	27.1	111	5 in.	25.214 in.	2,400 lb.
Summary	26.8 to 30.0	107 to 117 Horsepower	5 in. to 6 in.	25 in. to 34 1/2 in.	2,400 lb. to 4,590 lb.

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ON STEAM TURBINE DRIVES in a Western refinery, economical medium speed herringbone gears (2,250 to 3,600 rpm.) replaced costly high speed turbine gears for average requirements of 20 to 200 hp.



CONVERSION TO HIGH SPEED OPERATION of this originally low speed car wheel turning lathe at Southern Pacific's Los Angeles shop was completed at 10% the cost of a new machine through use of a Lufkin Gear Increaser driven by a Varidrive electric motor. Conversion of similar lathes has been made subsequently at SP's shops in San Francisco, Stockton, and Portland. (Both photos by Lufkin Foundry & Machine Company.)

ing a wise selection, the table at the bottom of page 3 provides a comparison of eight leading makes. All of the gears listed conform to the minimum standards of AGMA.

Caveat emptor (for gears, too)

What conclusions can be drawn from the table? One significant fact is that, although reasonably close in horsepower rating at a service factor of 1, Manufacturer "A" 's gear offers more than twice the weight of "H" 's. And the lighter gears with the smallest main shaft diameters and shorter center distances claim the greater horsepower ratings. Obviously, these gears are more closely tailored to minimum standards, and offer the buyer a minimum of reserve. Analysis, pricewise, would reveal considerable variation, and units offering minimum design will often bear higher price tags than their heavier, more conservatively built counterparts.

Something not mentioned in most gear catalogs is bearing life. AGMA minimums will permit from 25,000 to 30,000 hr. average life. The more conservatively designed of Gears "A" through "H" as listed in the table will offer bearings of 100,000 hr. or more average life.

It will pay a gear user to screen carefully the design features offered by individual gear manufacturers. A gear possessing the greatest combination of refinements will not always necessarily be the most expensive. Quite often, price may be in the lower economic brackets, due to specialization and high production by the manufacturer. Therefore, the old Latin term *caveat emptor* or "Let the buyer beware," prevails even in proper gear selection.

A good deal of confusion and bewilderment seems to exist among users of right angle drives when trying to compare worm gears with spiral bevels, due to the different AGMA terminology for the two types of gears, and due to differing service factors for the same kind of duty. Some illumination of this subject seems to be in order.

Clarification of service factors

First of all, *worm gears* are broken down into Classes 1 through 5 for varying types and duration of duty by AGMA, and each class has a specific service factor value, except Class 5, which goes by torque. *Spiral bevel drives* are not so classified. Service factors for these drives are selected in the same manner as for herringbone and helical gear drives, e.g., by "Character of Load."

For clarification, here is an explana-

AUTHOR OF THIS ARTICLE

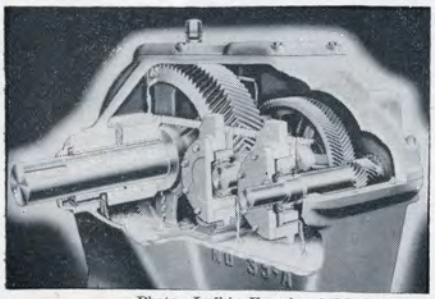


V. J. FAWCETT
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Los Angeles, Calif.

"Vic" Fawcett mentioned to WI editors many months ago that he thought Western buyers and users of gears needed certain types of basic information to aid them in making intelligent selections to achieve efficient and economical gear operation. This article is the result, compressing into limited space his broad knowledge gained from 20 years' observation of gear application in the West. A member of many technical societies and a native Westerner, Fawcett joined Lufkin in 1934, working with gear users in Southern California, and in 1950 was placed in charge of the Lufkin, Tex., firm's Pacific Coast industrial operations. Since then, except for a Middle East assignment to direct Turkish engineering personnel in the use and care of geared equipment, he has been working closely with gear distributorships and gear users in all of the West's manufacturing and processing industries.

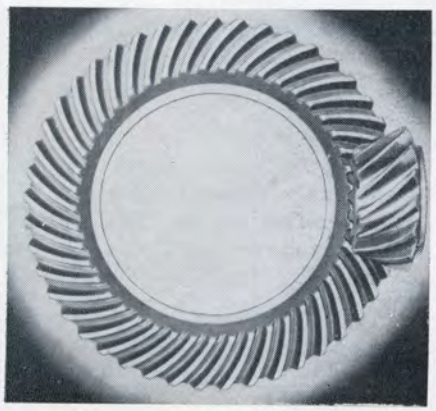
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TYPES OF GEARS



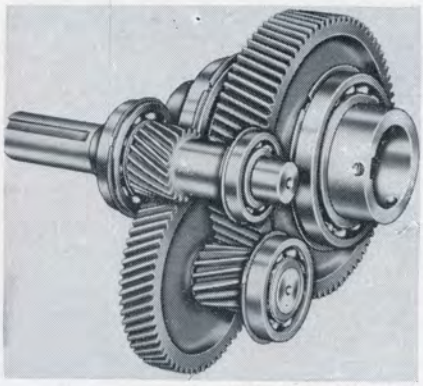
Photo—Lufkin Foundry & Machine Co.

HERRINGBONE GEARS—external herringbone or double helical gears are used when both high speeds and high horsepower are involved. When thrust exceeds limitations of single helical gears or plain bearings are used to support the gears, herringbone gears are used. External types have been built to carry as much as 60,000 hp. on a single pinion and gear. This type of gear is used in oilwell pumping, paving plants, pumps, fans, compressors in refineries, conveyors, compressors, pumps in chemical plants, pulp and paper mill operations, lumber mill operations, rubber mill drives, on cranes, hoists, elevators, cement mills, pipeline pumps, and in steel rolling mills.



Photo—Gleason Works

SPIRAL BEVEL GEARS—have curved, oblique teeth which are cut or ground to run with localized contact. Their gradual tooth engagement and overlapping tooth action results in smooth and quiet operation at high loads and speeds. This type of gear is commonly used in cooling tower fan drives, steel rod and tube mills and mining machinery, pulverizers, boring mill table drives and machine tool applications, marine propeller drives, winches and cranes, turbine drives, farm machinery, truck drives and earth moving equipment, aircraft accessory and high speed drives, helicopters, deep well pumping drives, printing presses, power hand saws, drills, nut setters, grinders, cloth cutting equipment and instruments.



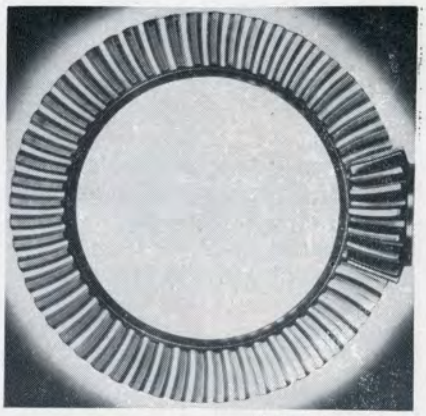
Photo—Dodge Mfg. Corp.

HELICAL GEARS—sloping teeth of a helical gear are generated in the cutting process and they provide an infinite number of thin gears in parallel, each of which comes into contact with the mating gear slightly behind the other, reducing chance of tooth error trouble. Noise problems often encountered in spur gears is eliminated with this type gear.



Photo—J. W. Minder Chain & Gear Co.

SPUR GEARS—are relatively simple in design and most equipment manufacturers prefer to use them where design requirements permit. Although they are usually thought of as slow speed gears, spur gears can be used at almost any speed if noise is not a consideration. Teeth, perfectly straight and parallel with the axis of rotation, may be cast or machined. Practical speed ratios run up to 10 to 1, but more-than-average noise is produced when operating at speeds over 1,000 fpm. Spur gears are available as internal as well as external units. When straight line motion is desired, it can be obtained through use of a spur gear and a rack.



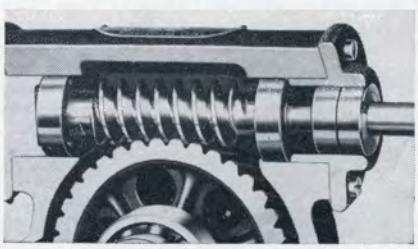
Photo—Gleason Works

ZEROL BEVEL GEARS—have curved teeth with zero spiral angle and localized tooth contact. They operate with the same thrust and tooth action as straight bevels. Commonly used in aircraft propeller reduction units, instrument planetary and differential systems, marine applications, reversing gears, and paper mill and steel mill shear drives.



Photo—Gleason Works

HYPOID GEARS—are similar to spiral bevels except for offset between the pinion and gear axis. They operate more smoothly than spiral bevels, can be used for higher ratios, and have increased strength of pinion member.



Photo—Abart Gear & Machine Co.

WORM GEARS—are ordinarily used on right angle drives when very high ratios are needed. They are also widely used in low to medium ratios as packaged speed reducers.

KINDS OF GEARS IN COMMON USE

PARALLEL AXES	INTERSECTING AXES	NONINTERSECTING NONPARALLEL AXES
Herringbone or helical external	Straight bevel	Crossed helical
Herringbone or helical internal	Spiral bevel	Single enveloping worm
Spur external	Zerol* bevel	Double enveloping worm
Spur internal	Face gear	Hypoid

*Registered trade name—see picture above.

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Tips from Westerners on buying gears

Here are actual comments from a number of Western gear users describing factors they find important in gear selection. Check your thinking with theirs:

FROM THE OILFIELDS—*Tal Ledbetter, Southern Division Superintendent, Production Department, Union Oil Co. of Calif., says,* "Oilfield pumping imposes sudden and severe loading on reduction gears. Heavy shock loads and load reversals occur with each cycle, 24 hr. per day, 365 days per year. Price is secondary to performance where trouble-free, uninterrupted performance is imperative. Only those gear manufacturers with outstanding performance records in oilfield duty are considered."

POWER TRANSMISSION SPECIALISTS—*Ernest Minder, President, J. W. Minder Chain & Gear Co., Los Angeles and Portland,* says, "In our thirty years as specialists in the manufacturing and distribution of power transmission equipment on the Pacific Coast, we have learned by practical field experience that, in the selection of gear drives, price should not be the determining factor and is never a substitute for quality."

FOR THE COOLING TOWER INDUSTRY—*James G. De Flon, Manager of Engineering, The Fluor Products Co., Whittier, Calif.,* insists, "In selecting right angle spiral bevel gears for induced draft cooling tower fan drives, the purchaser should insist that the gears be rated in accordance with American Gear Manufacturers' Assoc. standards using a service factor of 1.5 for 24-hr. continuous duty, electric motor drive. A gear rated 30 hp. by AGMA will have a rating in excess of 60 hp. by the Gleason scale of top hardness. Horsepower ratings mean nothing unless the buyer is aware of the process by which the rating was obtained."

. . . and *J. J. Finnerty, Purchasing Agent, Cooling Tower Dept., Foster Wheeler Corp., San Mateo, Calif.:* "When placing an order, a Cooling Tower Manufacturer OEM desires for induced draft fan service (1) That the gears furnished be manufactured in accordance with AGMA's standard practices and that the gears be certified to this effect. (2) That spiral bevel gears have the recognized AGMA service factor of 1.5. for 24-hr. duty. using electric motor. (3) Bearings must have a minimum B-10 life of 30,000 hr. (4) Gears must have a long record of proven dependability in cooling tower service.

"Price and delivery are prime requisites," says Mr. Finnerty, "but equally important is the reliability and adequacy of the vendor's service force and design features of the gear relating to maintenance and repair."

IN A CHEMICAL PLANT—*Dick Grundman, Chief Design Engineer, American Potash & Chemical Corp., Trona, Calif.,* seeks clarification. "We'd like to see uniformity and clarification of different gear manufacturers' methods of rating gears. Can't someone do something about giving us standard methods to make intelligent comparisons?"

HIGHWAY EQUIPMENT—*K. A. Anderson, Purchasing Agent, Madsen Iron Works, Construction Equipment Div. of Baldwin-Lima-Hamilton Corp., La Mirada, Calif.,* remarks, "A gear is only as good as the service organization behind it. Gear reducers employed in our paving plants must conform to AGMA standards and must be of rugged, sturdily built construction comparable, for example, to the design employed by the oil industry in heavy duty pumping service."

FOR AIRCRAFT TESTING APPARATUS—*Carl Starbeck, Design Engineer, The Arnolt Corp., Santa Monica, Calif.,* looks at gears this way. "Today, more than ever, precision workmanship and quality materials are imperative in the manufacture of aircraft equipment, whether of the airborne or ground supporting type. Gears employed in our manufacture of various testing apparatus must meet the most exacting standards, and have the backing of a good service organization."

FOR HEAVY DUTY PIPELINE AND BOILER FEED PUMPS—*Ed Lindsey, Regional Sales Manager, Byron Jackson Pumps, Inc., a subsidiary of Borg-Warner Corp.,* states, "Gears used in conjunction with our pumps must have proven performance history and must have the backing of a vigorous, readily obtainable service force. The reputation and performance of our products are partially dependent upon satisfactory operation of products manufactured by others."

IN LUMBERING AND MILLING OPERATIONS—*U. S. Plywood Corp's Bob Cox, Design Engineer of Associated Div., Gold Beach, Oregon,* puts it this way, "Only the most ruggedly built equipment will stand the gaff in lumbering and log handling operations. Heavy shockloading is the rule and gear reducers in our plants must perform under such punishment year after year."

IN PIPE ROLLING AND TANK MANUFACTURING—*Earl Babbitt, Production Engineer, Beall Tank & Pipe Co., Portland, Ore.,* has this to say: "Shaping and forming of steel, hot or cold, imposes severe peak loads and stresses on pipe rolling reduction gears, probably not exceeded in many other industries. Gears themselves must be good—shock resistant and durable—but equally important, housings must be heavy duty, heavy wall thickness, and heavily ribbed so that separating forces cannot disturb perfect shaft and gear tooth alignment."

tion of different classes of worm gears.

CLASS 1—Service Factor = 1 (Normal 8-10 hr. service, free from recurrent shocks, that is, shock loads that recur at even or frequent intervals. Multiply input horsepower by service factor of 1.0.)

CLASS 2—Service Factor = 1.2 (8-10 hr. service where recurrent shock loading is encountered or 24-hr. service where no shock load is experienced.)

CLASS 3—Service Factor = 1.3 (24-hr. shock load service.)

CLASS 4—Service Factor (Fractional) (Intermittent service where worm is operated at speed of 100 rpm. or more. Actual input horsepower is multiplied by varying factors from .6 to .9, depending upon frequency and the duration of the load.)

CLASS 5—For Class 5 service, rating of gear set is always given as output torque rating. The output torque rating for worm speeds below 100 rpm. is obtained by converting horsepower rating at 100 rpm. to output torque. To determine output torque rating of gear set, the following formula should be applied:

$$T = \frac{P \times 63{,}000 \times Mg \times N}{n}$$

Where T = Output torque rating in pound inches
P = Input horsepower rating
n = Worm speed in rpm.
Mg = Gear ratio
N = Gear efficiency

$$\frac{(100 - \text{Ratio})}{2} = \text{percent}$$

The efficiency of worm gears will run between 90% to 95% up to ratios of 10 to 1. Over 10 to 1 ratio, efficiency is equal to

$$\frac{100 - \text{Ratio}}{2}$$

For example:

Gear ratio = 60 to 1

$$\text{Efficiency} = \frac{100 - 60}{2} = 70\%$$

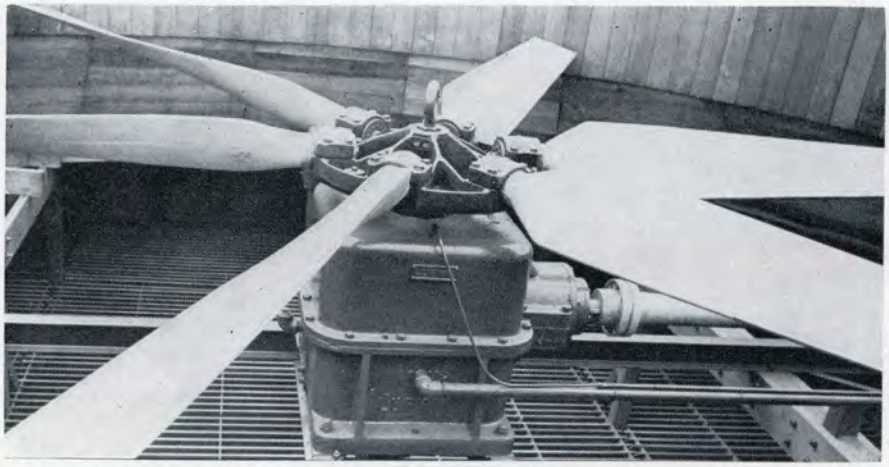
Now, as a direct comparison between *worm* and *spiral bevel* or *helical* gears, the following service factors are recommended for a specific type of duty:

Recommended AGMA Service Factors for Cooling Tower Induced Draft Fan Duty

Type of Gearing	Turbine or Electric Motor	Multi-Cylinder Gas Engine
Spiral bevel	1.5	1.75
Helical	1.5	1.75
Worm gear	1.2	1.3
Double enveloping worm	1.2	1.3

In the past, it is our understanding that spiral bevels, herringbones, etc., were referred to by classes, like worm gears are today, but this is no longer

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SPIRAL BEVEL GEARS, highly specialized and highly efficient for the application, have largely replaced standard automotive transmissions for severe 24-hr. duty in driving cooling tower fans. Here, a 60-hp. right angle spiral bevel gear reducer, ratio 9.17 to 1, in induced draft cooling tower service. (Photo by Lufkin Foundry & Machine Co.)

true, as demonstrated by the foregoing tables and examples.

Rating spiral bevels

Horsepower and hardness go hand in hand in the rating of *spiral bevels*, just as in other types of gears. A very considerable increase in the materials factor and hence in the horsepower rating is obtained, theoretically, by going to a minimum hardness of Rockwell "C" 60.

Therefore, it is very apparent that the point of the matter is the hardness held to by the manufacturer. AGMA recognizes the impracticability of maintaining and guaranteeing the manufacture of spiral bevel gears beyond its published top hardness of Rockwell "C" 55 which stops with a materials factor of 1.0, and its obvious protection to the purchaser. Conservative engineers will readily see that if it were possible to maintain the highest hardness, no gear manufacturer would offer gears except with the use of higher hardness, thereby being able to offer the highest possible horsepowers with the least material used.

Step-by-step gear selection

For an example of the factors that must be considered in the selection of a gear to do a given job, let's suppose you need a right angle spiral bevel gear to drive a 20-ft. induced draft cooling tower fan and that the source of power is an electric motor. AGMA bulletins, and manufacturers' literature based upon AGMA standards, provide tables indicating the shock loads to be expected from various drive situations.

First step is to consult such a table. The finding in this case would be that your cooling tower fan drive will be operating under moderate shock load conditions. Other tables in the same engineering literature have been set up to indicate the service factor to be expected from various prime movers under every possible duration-of-service condition for different load conditions. Using such a table, and supposing the drive will be operating 24 hr. a day, you would find that a service factor of 1.50 is indicated.

Next factor to be considered is horsepower catalog rating desired in the drive. The actual horsepower to be transmitted in this case is 100 hp. Horsepower catalog rating is determined by multiplying the transmitted horsepower by the service factor; or 1.50x100 hp. giving you a 150-hp. catalog rating.

Take a close look at efficiency

Before actually referring to manufacturer catalogs for selection of the gear unit, you should consider efficiency that can be expected from the type of gears involved as governed by the ratio of speed reduction. This factor hinges upon whether you can select a single, double, or triple reduction gear unit. For the sake of our cooling tower fan drive example, we will use an output speed from the motor of 1,750 rpm. and a desired speed of the fan of 175 rpm. This ratio of reduction, 10 to 1, can be handled by a single reduction gear unit. Engineering literature from AGMA or manufacturers of gear products lists this information. Other tables in the same literature will tell you the efficiency you can expect from a single, double, or triple reduction unit employing any given type of gear; you would find that your right angle spiral bevel gear unit, in a single reduction model, would perform at 98-98.5% efficiency. This factor should be considered when actually selecting the gear unit from manufacturers' catalogs.

When selecting gears from manufacturers' catalogs, select a gear size that is horsepower-rated equal to or exceeding the value you have established as a horsepower catalog rating for your drive; in this case, 150 hp.

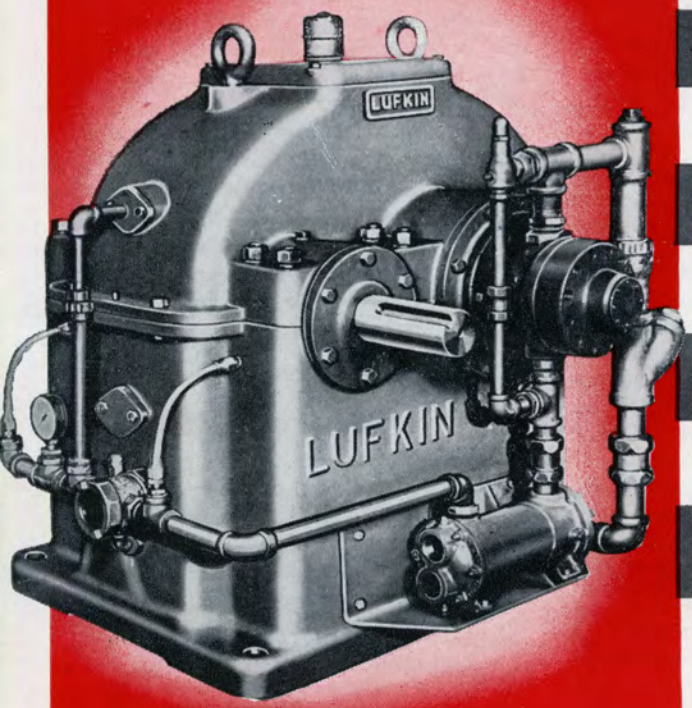
In conclusion we would like to make one broad recommendation to gear buyers, based on the sad experience of many purchasers over a period of many years: *select a gear with a service horsepower rating which is equal to or greater than the optimum horsepower rating of your prime mover and/or your driven machine.*

Here are ten more significant points to keep in mind when you are selecting and buying gears:

1. Gears should conform to American Gear Manufacturers' Assoc. standards.
2. Think of service. A gear product is only as useful as the organization that backs it. If the product is nationally distributed, be sure the gear manufacturer has national sales and service points.
3. Check for uniformity of selection and unit comparison.
4. Don't forget the importance of design, bearing life, case rigidity, and overall simplicity.
5. Remember that standard ratios are desirable for better delivery on original units and replacement parts.
6. Keep the "freight allowed" angle in mind. Most AGMA members allow freight to any railroad siding in the U. S. on standard gear units.
7. Check stocking or inventory costs of your standard gear requirements with gear source.
8. Lean on a reputable gear manufacturer for guidance in gear drive design best suited to your job.
9. Seek out a gear manufacturer specializing in your particular requirements.
10. Check the responsibility of the manufacturer for: (a) Repair parts' availability on old gears; (b) Proven service to industry.

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Lufkin HERRINGBONE GEAR SPEED REDUCERS AND INCREASERS



LUFKIN, TYPE N "HIGH SPEED"

ANY SIZE
3 TO 2000 H. P.

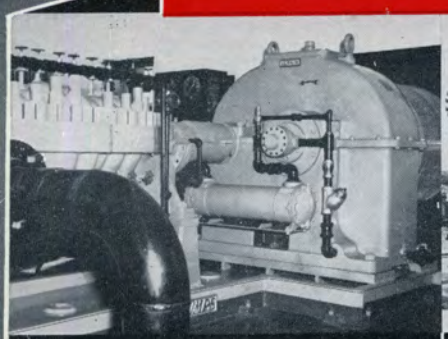
ANY SPEED
0 TO 12,000 R. P. M.

ANY RATIO
1 TO 1 TO 70 TO 1

ANY JOB

WHERE SPEED IS REDUCED OR INCREASED . . . . . .

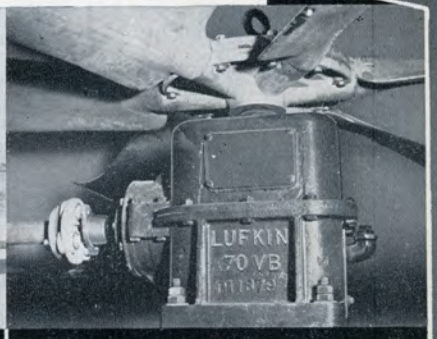
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PIPELINE PUMP



SALT WATER DISPOSAL



ALSO SPIRAL BEVEL REDUCERS FOR COOLING TOWERS

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