Main Switchboard. Desk type for controls, vertical panels in rear for instruments on main board of seven sections. All other boards of vertical type. Panels of slate. Mimic busses of all circuits with different finish for each voltage.

Circuit Breakers. Remote control, solenoid-operated, type O-2 and CO-2 on 12,000-volt circuits; type G-2 on high-tension circuits.

Emergency Lighting. Emergency lights throughout plant automatically transferred from normal supply to storage batteries in case of station trouble; restored when trouble is removed.

Telephone, Etc. Duplicate private branch exchange boards. Telephones installed in all parts of building and important points outside of station. Loud speaker on main instrument board permits operator to talk without head set.

Master clock in control room with auxiliary clocks in various parts of building.

Load indicator in center of boiler room firing aisle with double-faced illuminated dial electric clock and steam gage.

Signal System. Induction regulator type sending and receiving indicators and transmitters between control room and gage boards.

The Frequency Problem in the Steel Industry

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The standard frequency of 25 cycles for steel mill plants was adopted many years ago, when the conditions were such that this frequency more nearly met the steel mill requirements than was possible with 60 cycles. With the coming of large central power stations, for the general supply of electric service of all kinds, the frequency of 60 cycles has come into more general use. In consequence, in considering the purchase of power from the large supply companies, the steel mills are now confronted with the problem of utilizing 60 cycles to best advantage in plants which were initially designed for 25 cycles.

Various possibilities for utilization of 60 cycles in such plants are given, and the advantages and disadvantages of each are discussed briefly.

The intent of the paper is to bring forward certain points for free discussion, rather than to attempt to solve the problem, it being recognized that the whole matter is too complex and contains too many varied elements to allow any entirely satisfactory general solution.

SOME fifteen years ago, recognizing the advisability for standardization of certain requirements in connection with their work, the steel mill engineers took up the question of choice of frequency. At the time all the electric power used by the steel mills was produced in their own plants, and, in many cases, such plants were of relatively large capacity compared with central stations. Apparently there was no question then regarding advisability of the generation of their own power, as this was the only way in which they could obtain electric power.

At the time there were only two frequencies in general use in this country, namely, 25 and 60 cycles. The steel mill engineers, therefore, confined themselves to a comparison of these two frequencies, and their fitness for steel mill work in general. Various applications of electricity to steel mills then in use, and in contemplation, were gone into quite fully. The manufacturers of electric and other machinery were consulted quite fully regarding the possibilities of the various types of apparatus and equipment. At that time there were three conditions of service which required special consideration, namely, (1) the operation of large very low-speed induction motors; (2) the transformation from alternating to direct current; and (3) the parallel operation of low-speed gas-engine-driven generating sets. These three conditions will be gone into more fully.

At the time that this study was made, much of the

heavier service of the steel mills was contemplated at relatively low speeds with direct-connected motors, or with as little gearing as possible, on the basis that large, high-speed, high-power gears would not be satisfactory. As motors up to 6000-h. p. nominal rating, with speeds of 75 to 90 rev. per min. were considered necessary in certain applications, it appeared, from all points of view, that for such work 25 cycles was far better than 60, both from the standpoint of the general performance and the first cost.

In transformation to direct current, both synchronous converters (or "rotaries" as they are often called) and motor-generators were recognized as possible methods. With synchronous converters, 25 cycles offered by far the better proposition, compared with the 60-cycle synchronous converters of that time; whereas, with motor-generators, there was not much difference. With induction-motor drive, for motor-generator sets, naturally the lower frequency appeared to offer advantages, while with synchronous motor drive, the 60-cycle possibly was better. It must be borne in mind that in those days the high-speed d-c. commutating-pole generator, as we now know it, was not yet developed, and, therefore, with the then relatively low speeds of motor-generator sets, 25-cycle synchronous driving motors were fairly comparable with 60 cycles, while with induction-motor drive the advantage naturally was with 25 cycles. The coming of the commutating-pole d-c. machines, with consequent very much higher speeds, has greatly changed the situation, as will be referred to later.

To be presented at the 369th meeting of the A. I. E. E. in joint session with the A. I. S. E. E., Pittsburgh, Pa., April 16, 1921.

The third condition mentioned, namely, parallel operation, is one which concerned, principally, gas-engine drives. It was the belief that by using furnace gases with suitable large, low-speed, gas engines, the most economical generation of power would be obtained. The Gary plant is an illustration of this early tendency. It was well-known, at the time, that, with 25 cycles, parallel operation of alternators, with gas-engine drive, was a much easier proposition than with 60 cycles, and even with 25 cycles there were some doubts regarding successful paralleling.

This Gary plant should be referred to further as an illustration of certain extreme conditions undertaken in some of the earlier pioneering in electrification of steel mills. Everything was more or less new and special in this electrification and this was frequently cited as an illustration of an entirely electric-driven steel mill. In this early plant, there were many conditions of motor drive which, even with very low-speed motors, still required huge gears for still further reduction in speed. Some of the ultimate speeds, at the load, corresponded to six to ten revolutions with direct motor drive, obviously representing impossible conditions as far as direct motor applications were concerned. Even with gearing, the conditions of motor drive were such that 60 cycles would have represented impracticable conditions, so that 25 cycles was a practical necessity in this plant as designed. This Gary plant had a very decided influence in fixing 25 cycles as a standard for steel mill work.

Taking all the various conditions into consideration, the steel mill engineers decided definitely upon 25 cycles as their future standard for generating plants. A standard voltage of 6600 was also decided upon, although this was not considered as of first importance, but practically amounted to setting an upper limit. It was felt that there would be considerable use for lower voltages, such as 2200, and in fact, experience has shown that, in the smaller plants, 2200 volts is used more than 6600.

This choice of 25 cycles at that time, was undoubtedly the correct one, with the knowledge and experience available, and it may be stated emphatically that no real mistake was made in this choice of frequency. It may be said, moreover, that if 60 cycles had been chosen, instead of 25 cycles, at the time, it is probable that steel mill electrification would have been greatly handicapped in many ways and would not have reached nearly the stage of development that has been attained today.

However, new conditions have arisen in recent years which have changed the complexion of the problem to a certain extent. Fifteen years ago it was believed quite generally, that 25 cycles would be the future power frequency of the country on account of its general advantages in generation, transmission, utilization and transformation to direct current. If

this was true of the general problem, it applied still more positively to the steel mill situation. The whole trend for large power service seemed to be toward 25 cycles; but, for lighting purposes, 60 cycles was favored as being by far the more desirable frequency.

From the central station standpoint, however, the situation gradually changed. One of the big handicaps of the 60-cycle system was in the greater difficulties in transformation to direct current. The 60-cycle synchronous converter, while operative in a fairly satisfactory manner in some applications, was considered quite unsatisfactory in others. This, therefore, meant that motor-generators were required, to a considerable extent, in connection with 60-cycle generating plants, while with 25 cycles, synchronous converters were used almost exclusively. Thus the large generating plants for operating d-c. railway service and those for operating the three-wire d-c. Edison systems went almost exclusively to 25 cycles, mainly on account of the advantages of synchronous converters over motor-generators. However, improvements in the 60-cycle synchronous converter, making it a better operating machine, appeared about fifteen years ago, but nevertheless the machine, being of the non-commutating pole type, was of relatively low speed, with many poles, and was unduly complicated and expensive and inefficient. The coming of the commutating poles in d-c. generators was naturally followed, although several years later, by the use of similar poles in synchronous converters beginning about 1911. At first the use of commutating poles on synchronous converters was considered as unnecessary, and simply in the nature of a refinement, due to their relatively low speeds, and there was some truth in this. However, the use of commutating poles on synchronous converters immediately opened the way to very much higher speeds, so that within a year or two after their real introduction, the speeds of both 25 and 60-cycle synchronous converters began to climb at a rapid rate. Here, however, the 60-cycle converter had the advantage, for soon the 25-cycle machines reached their limiting minimum number of poles; whereas the 60-cycle machine could go to materially higher speeds before reaching such limits. Consequently, in this race toward higher speeds, the 60-cycle synchronous converter, in the smaller capacities, especially, soon outran the 25-cycle, while in the larger machines it made such a good showing relatively, that it put the 60-cycle generating system nearly on a par with the 25-cycle from the standpoint of transforming to direct current. Here was a big step in favor of 60 cycles.

In the development of induction motors, the tendency also was toward higher speeds. In the small sizes of 25-cycle induction motors, there is not much choice in speeds on account of the few combinations of poles which are possible. Here 60 cycles presented material advantages in offering very much higher

speed machines for general power purposes, with the resultant lower first costs. 1200 and 1800 revolutions, corresponding to six and four poles, respectively, became common practise on 60 cycles; whereas 750 rev. per min. was practically the nearest corresponding 25-cycle machine. Of course, two-pole, 1500 rev. per min., 25-cycle machines are possible, but it happens that, for constructive reasons, the two-pole machine does not show any material advantage in cost or otherwise over the four-pole machine.

From a third standpoint, namely, power generating units, 60 cycles also soon presented advantages. In the earlier days of the turbo-generator, the 25-cycle, two-pole, 1500-rev. per min. unit was favored over the 60-cycle, six-pole, 1200-rev. per min. of corresponding capacity. However, in the race toward higher speeds, which has occurred in the turbo-generator practise as well as in other lines of electrical design, the 1200-rev. per min., six-pole machine was dropped in favor of the 1800-rev. per min., four-pole machine, thus putting the advantage somewhat in favor of 60 cycles. Moreover, up to 5000 kw., a 3600-rev. per min., two-pole machine at 60 cycles became possible; whereas the best that the 25-cycle frequency could offer was 1500 rev. per min.

In transformer development, in the early days, it looked at first as if 25 cycles had all the advantage, due to the fact that the iron losses were relatively much lower and, therefore, the iron in the magnetic circuit could be worked at very much higher flux densities. However, with improvements in the quality of transformer steel, such as the introduction of silicon steel, it was found that with either 25 or 60 cycles the flux densities could be worked up to such a point that saturation of the magnetic circuit, and in consequence the magnetizing current itself, became one of the limiting conditions. Thus 25 cycles represented simply lower losses in the transformer iron, which were more than counterbalanced by the increased quantity of iron required, so that the advantage began to be on the side of the 60 cycles; and in later development the 60-cycle transformer, as a rule, has proved to be materially smaller, lighter and cheaper than its 25-cycle competitor.

Thus it may be seen from the few indications given above, that there were strong reasons for the trend toward 60 cycles for general power generation and distribution. The transmission advantages at first seemed to be in favor of 25 cycles. However, transmission voltages soon rose from 11,000 to 22,000, 33,000, 44,000, 66,000, 110,000, 132,000, 154,000, and now 220,000 is to be tried out soon, and with these higher voltages the 60-cycle transmission has proved to be sufficiently satisfactory; so that taking generation, transformation, transmission, distribution and the nature of the load into account, the sum total of the advantages has been considerably in favor of 60 cycles.

Another consideration must be taken into account, namely, fifteen to twenty years ago large control stations for general power supply were almost unknown. There were lighting stations and there were railway stations and there were power stations furnishing individual industries, but there were practically no central stations for the general supply of power for all purposes, as have developed during the past few years. With the gradual recognition of the advantages of centralized power plants, the smaller lighting and general power distributing stations began to expand and reach out toward the isolated and special service plants. Gradually as the central stations increased in capacity, they began to make special power rates to the railway companies and to the industrial plants, which were better than these plants could obtain from their own generating plants. Consequently, there was soon a tendency toward shutting down the individual plants, with purchase of power from the central plant. This action has been cumulative, for the more load that was taken over by the central plant, the bigger the central plant became, and the better rates it could make, etc. In this growth the tendency has been very largely, and in recent years almost exclusively, toward 60 cycles as a general purpose frequency.

Naturally, in reaching out for more load, these large central power plants have gone after the steel industry along with other industries, and here is where the steel mill problem of frequency has become prominent. As many of these steel mills, especially the older ones, are already equipped for 25 cycles, the problem has been that of best adapting the 60-cycle frequency where power is to be purchased.

In the former days, the steel mill could compete quite favorably with the central station in the cost of power. However, with the increased growth of the central power stations and their lower rates for power, the steel mills are naturally strongly tempted toward the purchase of power. Even though the steel power plant may be able to generate power as cheaply as it can be purchased, it still is not, in itself, an attractive investment as capital is not, as a rule, invested in the steel industry without the expectation of a reasonable return. As some of the steel mill engineers have said, their business is to produce steel and not manufacture power, and, therefore, naturally they cannot compete in many cases with those whose sole business is the manufacture and sale of power.

One condition which now lends itself toward the use of 60 cycles in steel mill work has been the increased use of gearing, thus allowing higher speed motors. For many kinds of service, gearing is now used where direct connection, a few years ago, was considered as the only method. In consequence, the speeds of the motors used in steel mill work will average much higher than a few years ago.

On the other hand, however, there are certain pre-

judices against large gears for heavy service, based to a large extent upon more or less unfortunate experiences. However, through greater experience and with more suitable types of gears, this prejudice is disappearing to a very great extent. As in everything else, there has been considerable development in the gear situation to meet many of the applications, and while there may be individual cases where gears are not looked upon favorably, yet it must be admitted that the general tendency in recent years has been quite strongly toward higher speed motors with gearing. Regardless of whether or not it represents the best engineering, the trend is toward such gearing, and, as a rule, where a trend persists it must sooner or later become recognized as desirable practise. The law of the survival of the fittest holds in steel mill machinery as well as in everything else.

Of course, it must be borne in mind that operative low-speed motors can be built as well for 60 cycles as for 25 cycles, but with either lower power factor or with high cost. In some cases, lower power factor may not be an important item. To state it plainly, with equal power factors, a low-speed 25-cycle induction motor is inherently smaller and cheaper than the corresponding 60-cycle motor. This is a fundamental difference. On the basis of equal costs of motors, with quite different power factors, additional cost of power factor correction should be included to make the two entirely comparable. It is, however, only in the low-speed induction motors that the 25-cycle frequency represents any material advantage. If, therefore, a plant should be made up largely of low-speed induction motors, the 25-cycle frequency would represent a most nearly ideal arrangement. However, there are very few plants, if any, where the larger part of the total power is utilized in such motors. Therefore, taking all the other service into account, it will probably be found that there are very few plants where 60 cycles cannot now make practically as good showing as 25 cycles. In other words, where the low-speed service represents but a relatively small part of the total service, it may be better to make some sacrifices in this smaller part to the advantage of the whole.

The question of purchase of 60-cycle power is dependent, of course, upon many conditions. In the Pittsburgh district, for instance, the total electric power used in the various steel mills may represent the equivalent of a huge power plant in itself. In consequence, if the various mills were to combine their power plants into one general plant, the capacity of such plant and the conditions of operation would probably be such that it could compete quite favorably with any large central station, and in such case 25 cycles could be the frequency. Moreover, this would remove the manufacture of power from the mills themselves and place it in a plant whose sole business would be the manufacture and supply of

electric power. It may be suggested at this point, that, at present, furnace gases are used to a greater or less extent under the boilers for power plants and that with the power plant placed elsewhere these gases would be wasted. However, there is not much doubt but that other uses would be found for such gases, and, in fact, some of the steel mills at present can find uses for all the furnace gases without burning them under the boilers.

However, in considering a single large power plant, the Pittsburgh district represents very unusual conditions in that there is a concentration of many huge steel plants within one relatively limited district. A combined steel power plant in the Pittsburgh district would, therefore, represent a very special rather than a general condition and would furnish the solution of the problem for only one general district. In other districts the problem of 60 cycles versus 25 cycles would still hold and would have to be met. Therefore, it is the general problem rather than a special one which should be considered broadly.

With this question of purchase of power before them, a number of the steel mills throughout the country which have been planning to increase their power plants, are faced with the question of installing additional plant at 60 cycles instead of 25 cycles; also, with their existing 25-cycle plants, the purchase of additional power at 60 cycles involves numerous problems in the application of such power to the existing equipment. Various suggestions have been made from time to time as to how to handle this situation in its various forms. Probably as good a way as any to look into the problem would be to classify the various methods by which the double-frequency situation could be met. These methods may be given as follows, the order in which they are given, however, not representing their expediency or importance.

1. Rebuilding, or allowing to become obsolete, the existing plant and replacing entirely with 60 cycles.

2. Conversion of 60-cycle purchased power to 25 cycles by frequency-changers and operating in connection with existing plants. This retains the advantage of the existing 25-cycle system but means, however, considerable losses due to the frequency-changers.

3. Allowing the existing 25-cycle plant to remain in service, and installing new generating and motor equipment for 60-cycle. This would allow purchased 60-cycle power to be utilized in connection with the new generating plant. This, however, involves a more or less mixed system throughout the plant.

4. Retaining the existing 25-cycle plant for those parts of the service where 25 cycles is materially better, and changing other parts to 60 cycles for use on purchased power. This could be continued until the old plant and equipment became obsolete. This would probably mean a mixed system throughout the mills for years to come.

5. Utilizing the existing plant within certain areas and applying 60-cycle purchased power to extensions and new areas. This involves a double system, but not a general mixture of two systems in the same areas. Eventually if the purchased power proves more satisfactory than the local supply, the latter could gradually become obsolete. This means, however, that in the new areas the 60-cycle frequency would be applied to low-speed motors as well as all other apparatus.

Looking at the matter broadly, it does not seem advisable to generate two separate frequencies in the local plant. In other words, if 25 cycles is the existing frequency, it is not desirable to put in an additional generating plant at 60 cycles, unless such new equipment is to be of greater capacity than that already installed. In this latter case it might be advisable to put in the additional plant of 60 cycles, simply with the understanding that the older small 25-cycle plant will soon be superseded entirely. In other words, the only condition under which the two frequencies should be mixed in the one generating plant, is where one of them is to be abandoned entirely within a reasonably short time. Wherever the additional plant, however, is to be less in size than the plant already installed, or simply represents the normal growth, then it appears that it would be better to put in the additional plant at the same frequency, rather than mix the two frequencies.

Some of the large central stations throughout the country have encountered a similar problem. In some of these cases both 25- and 60-cycle generating units have been installed in the same power plant, but as a rule, they supply quite different service and areas. For instance, the 25-cycle service will be utilized almost entirely by conversion to direct current, and within a given district this will apply exclusively. In other cities the 60 cycles may be represented by entirely separate power plants supplying outlying districts mostly, a large part of the application being by direct service instead of by conversion to direct current. As far as the writer knows, in general, the two services are not mixed indiscriminately. In the earlier days where 60-cycle service came into considerable demand in connection with 25-cycle plants, frequency-changers for giving 60 cycles were installed in many cases. As the 60-cycle service grew, instead of adding more frequency-changers, whose sole function is to change frequency, not to generate power, the practise has been to install 60-cycle generating units often in separate power plants, the existing frequency-changers then being used as a tie between the two plants. In those cases where the capacity of the two power plants has been very considerable compared with the capacity of the frequency-changers tying them together, there have been certain conditions of unusual stresses in the frequency-changers at times of severe load conditions. In other words, if the link, tying the two plants together, is a relatively

weak one, sometimes it may be broken. This problem of the two frequencies has been one of long standing with the central power stations, and as the present solutions are more or less a development from experience, this is possibly an indication that steel mills should follow along somewhat similar lines.

It has been suggested that in the application of 60 cycles to steel mills, this might be used largely for one kind of service such as the motor-generators or synchronous converters, for producing direct current. In this way the 60-cycle service need not be distributed so generally throughout the mills, but would simply be supplied to the converting machinery which is not scattered through the mills in the same way as the motors. Moreover, the modern 60-cycle synchronous motor-generator is just as cheap and economical as its 25-cycle competitor, or cheaper in some cases, while the 60-cycle synchronous converter, if transformers are included, approaches pretty close to the 25-cycle in general operating characteristics.

In existing mills, however, changing to 60 cycles would mean replacing or remodeling, at very considerable expense, the existing motor-generators and synchronous converters, and unless the future growth of such apparatus is to be very large compared with that already installed, this reconstruction or replacement might prove in the end to be relatively expensive, perhaps as much so as the installation of frequency-changers, which would allow the continuation of the existing 25-cycle frequency. Even if the existing machinery is more or less out of date, unless it has uneconomical characteristics, it can probably be kept in service for many years to come, for much of this machinery is well built and of durable construction and may still have twenty to thirty years of good operative life. In fact, some of the motor-generators and synchronous converters which have been in operation for ten to twenty years in steel mills appear to be as good as when first installed, and it will be difficult to justify their obsolescence and replacement.

Something might be said further regarding frequency-changers. As stated before, the function of the frequency-changer is simply to change frequency at a considerable expense in power. There are other objections outside of inefficiency which count against the frequency-changer, but these probably would not be dominating or controlling in themselves. On the face of it, the frequency-changer seems to furnish such a simple solution of the frequency problem that in some instances it might pay to sacrifice other considerations in favor of simplicity.

It must be kept in mind, that there are no means for getting the exact 60 to 25 relation with an economical type of machine, for the numerical ratio of 60 to 25 only allows a 24-10 pole combination, which represents a rather low speed except for units of enormous capacity. If any other more economical combination of poles is chosen, such as 10-4 or 14-6,

then, with a 60-cycle supply system, some other frequency than 25 cycles will be obtained. The 10-4 pole combination gives 24 cycles, while the 14-6 pole combination gives 25.7 cycles. Therefore, for either of these combinations, it would be necessary to change the steel mill frequency slightly, for it would be almost impossible to get any general power company to change its frequency of 60 cycles. Naturally, if either of the above combinations were to be adopted, the 10-4 pole would be preferable from the standpoint of the frequency-changer itself. However, there might be some question regarding the use of 24 cycles instead of 25 cycles in steel mill applications, for this means a general reduction of 4 per cent in the speed of all synchronous and induction motors. Thus the choice of the most advantageous speed for the frequency-changer may possibly represent a material disadvantage in the motor equipment. Again, the use of the 14-6 pole frequency-changer would mean increasing the mill frequency about 3 per cent, which should not be as objectionable as a reduction of 4 per cent. However, the 14-6 pole combination would not represent nearly as cheap frequency transformation.

As affecting the cost of the frequency-changer and its losses, there may be considerable saving over the installation of corresponding capacity in additional power generating plant. In installing new or additional power plant, the cost of the electric machinery represents but a small part of the total cost and, unquestionably, the extra buildings and equipment, to go with the frequency-changer, would be very materially less than that of additional generating plant. This saving in first cost, in some cases, might go a long way toward offsetting the losses of the frequency-changer, especially in those cases where 60-cycle power can be obtained at a very low rate. However, no definite statement can be made as to the comparative costs, because each case would have to be worked out individually.

As soon as two or more frequency-changers are to be installed in one plant, these to be operated in parallel with each other and with the existing generating plants, then complication comes in, possibly to such an extent as to lose most of the simplicity of the scheme. The synchronizing and proper paralleling of two or more frequency-changers with each other and with their respective power plants, is one of the "fussy" things which can be carried out successfully, but which nobody likes.

Attention should be called to the fact that if any particular combination of frequency-changer sets is chosen such as represented by 10-4 poles, or by 14-6 poles, then this exact ratio must be retained throughout, if additional frequency-changers are ever to be added to the plant. It is obviously impossible to parallel two combinations of poles which do not have the same ratio.

As to the capacities of such apparatus which are practicable in single units, 10-4 pole sets of 5000-kv-a. capacity have been offered recently by manufacturers. However, for larger capacities than 5000 kv-a. certain difficulties arise, as the next possible pole combination is 20-8, which represents just half the speed. In consequence, even with a 10,000-kv-a. set, halving the speed will probably more than offset the gains in cost and efficiency resulting from larger capacities. One would assume, in consequence, that two 5000-kv-a. units would be preferred to one 10,000-kv-a., and presumably this is correct, if the two units can be operated independently. For parallel operation, however, the added complexity might be considered sufficient to offset a slight increase in cost of the larger single unit.

For costs and efficiencies of such apparatus, the following very approximate figures are suggested.

For a 5000-kv-a. set including auxiliaries, switch-board appliances, etc. from \$10.00 to \$11.00 per kv-a. The combined efficiency will be approximately 92 per cent or better at full load and 89 per cent or better at half load.

For a 10,000-kv-a. set, having 20-8 poles, the cost per kv-a. could be taken roughly at \$11.00 to \$12.00. No figures for efficiency have yet been worked out.

Neither of the above approximations includes cost or efficiency of step-down transformers.

There is one other class of electric machinery used in steel mills where the effect of frequency has not yet been considered, namely, in the induction-motor speed-regulating sets which are coming into use to a considerable extent in recent years. There are three types of such speed-regulating appliances in use today, all of them requiring commutating machinery, namely, (a) those in which the secondary electrical power of the induction motor is transformed into mechanical power and utilized as such; (b) where the secondary electrical power is transformed into direct current and utilized; and (c) where the secondary power is transformed from the variable or adjustable frequency of the secondary to some fixed frequency such as that of the line and thus utilized. The first of these schemes involves polyphase commutating type motors; while the second requires synchronous converters; and the third requires commutator type frequency-changers, which are a more recent development than the other types of machinery mentioned.

From the standpoint of commutation, (a) and (c) present considerable advantages in first cost, general performance and efficiency at 25 cycles, as compared with 60 cycles, while method (b), involving synchronous converters, makes its best showing at 60 cycles, although all three arrangements are practicable at both frequencies. Arrangements (a) and (c) allow satisfactory operation both above and below the synchronous speed of the induction motor; whereas, (b),

heretofore, has only been worked below synchronism, although auxiliary means may be found for this scheme just as with the other two, for successfully passing the synchronous speed condition. All these methods of speed control will doubtless be used to a considerable extent, depending upon the conditions and the applications, but as they can be operated successfully on both 25 and 60 cycles, apparently they will have no controlling influence on the choice of frequency.

In conclusion, it may be said that there is no good general solution to this frequency problem and each case must be handled on its merits, taking the future tendencies and growths into account. In many cases it appears that the large existing 25-cycle local systems should be retained at least until such time as the need for replacement is more obvious than at present. Unless the future service of the mill shows strong inclinations of going almost entirely to 60 cycles a mixed generating plant is not to be recommended. In those cases where existing 25-cycle power and purchased 60-cycle power are both to be used, they should at first have their own individual services or areas, as far as possible, to avoid indiscriminate mixing of services throughout the mills, and to avoid frequency-changers, with their attendant losses, unless conditions are such as to warrant their use. In general, where both frequencies are liable to be used for some time to come, and there is any real necessity for a tie between the two, then frequency-changing becomes a necessity. However, as central station service has

now become quite reliable there is not the need for a tie between two frequencies that was formerly the case, so that doubtless, in many cases, frequency-changers can be dispensed with. In case of a new plant, even where it expects to generate its own power, in general it should be installed at 60 cycles, if located in a 60-cycle district, simply on account of future possibilities. There is no question whatever that future central stations will supply power for general purposes, at 60 cycles, within certain large districts, the trend being too strong to be changed or controlled. In other large districts it will be principally at 25 cycles, as in the territory served by Niagara, for instance. There will be still other cases where both frequencies will be used, simply because the field for 25 cycles is already so large that 60 cycles cannot replace it. In New York City, for instance, 25 cycles is already in use on such a vast scale (1,099,600 kv-a., 25 cycles, and 217,000 kv-a., 60 cycles) that it may be almost a lifetime before the 60-cycle service overtakes it. But the present growth in 25 cycles appears to be limited to existing plants, many of which may never be replaced by 60 cycles. In consequence of this mixed service, the ultimate solution of the general supply problem may mean 60 cycles for general purposes with 25 cycles as an auxiliary supply. It may be assumed that in those cases where 25 cycles presents such advantages that the consumer will put in his own generating plant, if necessary, to obtain such service, that eventually the general power service will find some means for supplying the individual case.

FOREIGN PATENTS

Those inventors who have interest in foreign patents should note that at the present time many changes are being made in continental and other patent laws, which need to be watched if it is desired adequately to protect the inventions in Europe or in the greater part of the world. A new law has recently been provided in Jugo-Slavia which brings this matter into prominence. Protection of industrial property is now uniformly regulated for the whole of the kingdom of the Serbs, Croats and Slovenes, and all protections which have been obtained in any part of Jugo-Slavia, either in the former kingdom of Serbia, or in Austro-Hungarian territories, which were in force at the end of last year, must be re-filed if it is desired properly to protect the invention throughout the kingdom of Jugo-Slavia.

The provisions of the new law correspond largely with those of the old Austrian Patent Law, and therefore exclude from protection matters which are Government monopolies. It is not usually known in this country how far these monopolies extend, so that it is well, before deciding on any particular patent application to be lodged in the new kingdom, to inquire of authorized parties. Explosives, tobacco, certain kinds of paper, and petroleum are among the subjects for which valid patents cannot be obtained.

Among other countries in which modifications have been made in connection with Patent Laws recently there may be named Roumania, Esthonia, Greece and Hungary.—*The Engineer*, London.

GEORGIAN WIRELESS STATION

According to an issue of the Near East for February 3, 1921, the Georgian Ministry of Supplies has concluded an agreement with a French trading and financial company for the erection of a powerful radiotelegraphic station in Georgia, by means of which it will be possible to communicate within a radius equivalent to the distance between Tiflis and London. The new station will connect Georgia with large European centers, such as Paris, London, Rome, Moscow and others.

According to the agreement, the Ministry of Supplies is to pay for the erection of the station by means of a consignment of tobacco. The station is to be erected within the next six months. At the same time another agreement under the same conditions was signed for the erection of four wireless telephone stations in various parts of Georgia. The central wireless telephone station will be erected in Tiflis.