APPLIED SCIENCE.

THE past few months have been busy ones in those departments of applied science which come within the scope of engineering. Indeed, the daily widening of that scope is bringing within its limits many things which were formerly considered altogether beyond the province of the engineer. So, too, it is impossible to discuss the progress of applied science within definite time limits. The subjects overlap each other and are interwoven to such an extent as to render it necessary to make any review such as the present rather elastic in its boundaries.

Although it is more than a hundred years since the first "Montgolfier" made its initial ascent, the problem of navigating the air is still unsolved; and there is every reason to believe that it will not be solved by any startling invention, but rather by the general progress of engineering development, carrying this undertaking and many others along with it. At the same time, the subject of aeronautics has attracted much attention very recently, for reasons which will readily appear. Aerial navigation demands the combination of two elements — one the sustaining, the other the propelling power. The former may act through buoyancy — a balloon, or through the supporting action of extended surfaces — an aeroplane; but the success of the latter has long been understood to depend upon the production of some light and powerful motor. Curiously enough, the motors which have rendered possible the recent dirigible balloons of M. Santos-Dumont and others were originally devised for land propulsion — for use on automobiles — and the reduction in weight which has been attained for motor vehicles on the surface of the earth is the real cause for the renewed attention which has been given to the dirigible balloon. The reduction in weight secured by the use of the gasoline motor will be seen from the following data.

The experiments of M. Tissandier in 1883 with a balloon equipped with a propeller driven by a primary battery and electric motor showed a weight of 150 pounds per horse-power, altogether too great to be practicable. Renard & Krebs, in 1884, succeeded in reducing the motor weight to fifty-five pounds per horse-power, and thus were able to carry nine horse-power in their balloon, "La France," and to drive it over a determinate path at a speed of fourteen miles an hour. M. Santos-Dumont, however, has been able to secure gasoline motors weighing twelve pounds only per horse-power; and with a motor of eighteen horse-power he has attained speeds of eighteen to twenty miles per hour.

The weight of motors can be still further reduced for larger powers. Builders of gasoline engines have designed motors of fifty horse-power weighing but eleven pounds per horse-power, and of 100 horse-power weighing only 6.6 pounds per horse-power.

Lord Kelvin recently expressed himself as of the opinion that all this experimenting with dirigible balloons will lead to nothing; and, with the exception of the stimulus given to the reduction of motor weight, this is probably correct. The aeroplane offers far greater useful possibilities, but the immediate results cannot be so showy. In this connection attention may be called to the continuation of the experiments of the lamented Lilienthal in sailing flight by the brothers Wright, in North Carolina. By devoting especial attention to the question of balancing, including the placing of the operator in a horizontal position, the practical management of the sailing aeroplane has been materially advanced; and it is to the combination of some such apparatus with an exceedingly light and powerful motor that we may look for real progress in the conquest of the air. Accidents, such as that which caused the death of Severo, in Paris, need not discourage experiment, but should serve only to emphasize the necessity for caution in design and operation.

The exhibition of motor-boats at Berlin exemplifies the development of small, light motors other than steam. Indeed, the rapid progress of the internal combustion motor generally is a matter for interested observation. This is especially true in connection with the continued exploitation of petroleum districts; and, with the efforts which are being made to introduce fuel oil, the use of various forms of motors in which it may be burned is to be expected. In addition to the Texas oil fields, the borings for oil in the Dutch East Indies are progressing, with good results, especially in the residency of Rembang, in Java. A number of years ago the introduction of fuel oil on American railways was retarded by an announcement, more or less official, from one of the great roads, that the fuel consumption of its engines alone would be sufficient to advance the market price. Since then the development of new fields has greatly increased the output, while improved methods of combustion have increased the efficiency; so that the situation is somewhat modified, and may be even more so in the closely approaching future.

Closely allied to the question of petroleum, from an engineering point of view, is that of the development of existing and newly exploited coal fields. The continual drain on the coal districts of Great Britain has drawn attention to the influence of fuel supply upon commercial and manufacturing supremacy. Apprehensions as to the ultimate exhaustion of the coal supply of the world are entirely premature; and, indeed, it has been pointed out that the world's supply of free oxygen may possibly be exhausted before its fuel gives out. The development of the coal supply, however, will inevitably cause more or less shifting of industrial centres, and the possession of the most accessible and valuable coal districts may determine the fate of nations. The control of the Pacific must be largely a question of coal resources; and in this connection the exploiting of the enormous coal deposits of Alaska, situated as they are on the great-circle route between Puget Sound and Japan, is a matter of present importance.

The engineering value of fuel is dependent not only on advantageous mining, but also upon the development of efficient methods of use. While it is eminently unsafe to predict the limitations of any line of scientific progress, yet the improvement of the steam-engine may confidently be expected to proceed along the lines of least resistance. The most careful analysis of the causes of loss in the steam-engine has shown the greatest to be that of condensation in the cylinder. Of the various methods of reducing this loss the use of multiple cylinders, reheaters, steam jackets, etc., appears to have been carried to a practical limit.

Hence we have a revival, with all the advantages of modern constructive methods, of the practice of superheating the steam before it enters the cylinder to such a degree as to permit a high expansion ratio with greatly diminished internal condensation. The most recent results in this direction have been very gratifying; a horse-power having been obtained with as low an expenditure as 8.6 pounds of coal per hour. Constructive and operative difficulties are naturally encountered in working with steam heated from 400 to 500 degrees above the temperature due to its pressure, and engines for use with a working fluid at such temperatures should be built especially for the service. Sliding and Corliss valves give place to lift valves; metallic packings of special construction become necessary; and ample provision must be made for the prevention of distortion from unequal expansion. These facts have led to a realization of the adaptability of the steam turbine for use with superheated steam. The freedom from rubbing surfaces and close fits to be affected by the high temperatures, and the absence of a lubricant to be carbonized by the heat make the turbine particularly suited for operation under conditions extremely difficult to meet with reciprocating engines. Recent tests in Germany have demonstrated the entire practicability of using steam turbines to obtain the manifest economy due to superheating.

Another feature of recent investigation in steam-engine design and operation is that of speed regulation. Formerly the requirements as to uniformity of speed were based upon the maintenance of a determinate number of revolutions per minute; and if the variation was not more than two or three per cent from normal the regulation was considered satisfactory. With the introduction of the system of operating alternating electric generators in parallel, however, the imperative condition is the maintenance of a nearly uniform angular velocity during the entire course of each revolution; a requirement especially difficult of attainment when it is remembered that the action of the steam upon the piston as transmitted to the crank is both intermittent and variable. Some interesting investigations into this subject have been made both in Europe and America. Thus, in France, M. David has employed a vibrating tuning-fork to trace upon a revolving disc on the engine shaft undulations representing equal intervals of time during a revolution; and a comparison of these with equal-spaced divisions on the disc enables the variations in angular velocity at any point of the revolution to be seen. In the light of information gained by these and similar investigations, it has been found possible to add damping devices to the engine governors in such a manner as materially to reduce the angular variations in any one revolution, and at the same time maintain a satisfactory general speed regulation.

In the course of the development of marine engineering some interesting features may be noted. Two disasters have served to emphasize the great advantages of twin-screw propulsion. The total disabling of the "Etruria" and her long and tedious tow have undoubtedly decided the fate of the single screw; while the loss of the rudder of the "Deutschland" and the successful manner in which she was controlled by the skilful use of the twin screws emphasized still more the advantages of the divided propulsion. There appears to be little doubt that the single screw is doomed, at least for Transatlantic express service.

Of the economic questions connected with the merger of the Atlantic steamship lines, this is not the place to speak. At the same time the possible suppression of competition may have a bearing upon the construction of record-breaking vessels, and tend rather to encourage the building of large and comfortable ships, of fairly good speed and profitable capacity. The tendency toward extreme speeds, attained only by excessively high powering, and to gorgeous and elaborate decoration, often in questionable taste, has been the result of striving for business in the strong competition of rival lines. Already marine architects are giving greater attention to comfort than to excessive display; wisely realizing that convenient accommodations below appeal strongly to the many passengers who must spend the greater part of their time in their cabins. Thus, the so-called "tandem" staterooms, in which an L-shaped construction gives the inside rooms access to portholes in the ship's side, are an evidence of practical engineering design in a welcome form.

The increase in the size of steamships appears to continue, governed only by the port limitations as to harbor draught and docking facilities. It is more than probable that these conditions, rather than existing commercial arrangements, may control the establishment of termini, the united action of steamship lines and railway companies being final in these respects.

Closely connected with engineering in the merchant marine comes the question of the agitation for reform in the position of engineers in the navy. In the United States the benefits intended to be gained by the enactment of the Personnel Bill have been almost entirely lost by a lack in executing the spirit of the act. The intention was to realize the terse statement of Mr. Roosevelt, then Assistant Secretary of the Navy: "Every officer on a modern war vessel has to be a fighting engineer." The failure to execute the law in this spirit has resulted in depriving the service of many of its ablest engineers, without replacing them by competent or suitable men. The mechanical work is now largely performed by warrant machinists, and the result cannot be gratifying to the nation or beneficial to the service.

In the British navy a similar state of affairs exists, except that legislation has not yet been reached. In that navy, however, one observes the same shortage of engineers, the same increase in engineering requirements, and the same disposition to relegate engineering responsibilities to machine-shop artificers. The whole matter is the result of the unwillingness of the line and executive officers to realize — what every one else has long ago known — that changed conditions have rendered their calling practically obsolete in its old form. Fighting, both at sea and on land, must henceforth be performed mainly by engineering methods, and it is inevitable that the control of warfare must fall into the hands of the engineering profession. There is good reason to believe that the idea of a "Great War Syndicate," humorously imagined by the late Frank R. Stockton, may become a reality in the main, if not in detail.

In civil practice, at least in America, conservatism has less opportunity than in government affairs. The transformation in methods and appliances — a revolution which, peaceful in its nature though it be, is altering the whole conduct of the civilized world — continues with increasing power. In mechanical engineering, at least, there is no lack of perception of the reality of the change. The skilled mechanic is daily becoming of less importance as regards numbers or wages, and of more importance as regards intelligence and ability. Skilled workmen at the machines are becoming less and less necessary, so far as the accuracy of the product is concerned, while the output has been vastly increased in proportion to the labor employed.

The modern system of using limit gauges for the inspection of material and for the determination of finished dimensions has rendered the old skill of the machinist with scales and calipers almost unnecessary at the tools. The introduction of improved tool steels, permitting far heavier cuts and higher cutting speeds than formerly, has increased many times the earning capacity of existing machine tools; while the independent determination of the maximum product of each machine in the minimum period of time has in many establishments rendered the determination of labor cost a matter practically independent of the machine tender himself.

The result of all this has been to remove much of the difference in the labor cost of manufactured articles in different countries, rendering the question of wages a minor one in international competition. At the present time the United States is able to compete successfully with countries in which far lower wage rates prevail; the controlling question being not the daily wage of the man, but the wage cost of the articles. When it is realized that until recently the non-productive charges in manufacturing establishments equalled the productive labor charges, it will be seen how important it has become to increase the output to the maximum, in order that the proportion of expense charge to be borne by each manufactured article may become a minimum. These questions have been receiving constantly increased attention of late, and the influence of engineering upon economics is daily becoming greater.

In another sense, also, is the engineer becoming influential in international economy. Under the old theories of political economy the operation of natural laws was assumed to be unquestionable, and the deductions logically made from such assumptions were held to be absolute and final. Within the last few months it has been shown, however, that individuals may command, in a manner altogether arbitrary, engineering resources controlling transport, production, and even consumption. The heads of governments are in some instances shown to be powerless, as in the case of the merger of the Atlantic steamship lines; and in numerous matters of commerce, trade, and industry the influence of engineering considerations is predominant.

An example of the possible dislocation of existing commercial matters is seen in the manner in which the substitution of electricity for steam for main-line railway traction is regarded. In nearly every instance the question is considered not merely as a technical problem, but as an economic one. In other words, what is discussed is not the cost of installing the new system so much as the enormous sum involved in the throwing away of the old one. The magnitude of the question is seen when it is stated that M. Sauvage, one of the best railway authorities in Europe, estimates that there are at present in operation about 140,000 steam locomotives, valued, at a low estimate, at $1,000,000,000! The advantages of electric traction must be demonstrated to be great indeed in order to warrant the "scrapping" of such a mass of operative machinery. Here, again, a question of engineering economics enters. The cost of motive power in railway service is estimated at about forty per cent and of labor at sixty per cent, and on this basis the influence of any economy in motive power would be less than one-half that which would appear from a direct comparison of fuel costs. When it is considered, however, that the operating expenses practically equal the labor cost, it will be seen that the item of fuel is really only about twenty-five per cent of the total cost. This means that even if electric traction were capable of saving one-half the fuel now required for steam locomotive traction, an altogether unwarranted assumption, the economy in total expense would be but twelve per cent.

As a matter of fact, the most recent experience indicates that electric traction will enter as an auxiliary to the steam locomotive, that it will be used for suburban and local traffic, while powerful steam locomotives will retain their preëminence for hauling heavy through trains of high speed. The transition will thus come gradually; the steam locomotives being "scrapped" as they are superannuated, and improved methods gradually replacing them. The same economic considerations apply to the performance of steam locomotives of various kinds. In the comparison between English and American locomotives in Egypt, the report recently made to Lord Cromer shows that the American engines consumed more fuel than those of British make. When the relative importance of fuel consumption to general expense is considered, as shown above, the impossibility of drawing any instructive conclusions can be realized. Engines proportioned for hauling maximum loads are built for capacity, rather than for fuel economy; and when maximum train loads are not provided the fuel economy naturally fails to appear. In the question of British versus American locomotives the pertinent question has been asked, and as yet remains unanswered: "If British engines are so greatly superior in performance to American ones, why does it cost about four times as much to haul a ton of freight in England as it does in America?"

Among the modifications in social matters due to engineering influence may be mentioned a suggestion which yet has to be converted into a reality. The overcrowding of cities has grown to be a serious question, and the means which have been thus far taken to remedy some of the evils of the congestion have not been very effective. Nearly all the efforts have been in the direction of better internal transport. More electric street railways, underground railways, etc., etc., have been undertaken; while, as a matter of fact, such increased facilities serve only to attract more people to a metropolis, thus directly encouraging an increase in the congestion intended to be relieved. Properly devised applications of electric traction, not to make it more convenient to stay in the city but to render it easier to get out of it, would check the congestion by encouraging suburban residence not only for the well-to-do, but for those who seek, in the bustle and glare of a metropolis, a relief from the dulness and monotony of the small town. If the heart of a great city, with all its attractions at night, were quickly, cheaply, and comfortably reached from many neighboring small towns, the tendency to flock to the city as a permanent place of residence and occupation would be checked and the population distributed. Such is the theory, and it will undoubtedly soon be put to the test of practice.

The question of local transport is one which, like the poor, is always with us; but it becomes more pressing in some localities than in others. There is probably more congestion on the Brooklyn Bridge during the crush hours than at almost any other place which could be named, and numerous propositions have been made with respect to its relief. Of these one of the most promising is that of an adaptation of the so-called travelling sidewalk, which has been suggested very recently by the chief engineer, and which, it is to be hoped, will be put into execution. The experience at the Paris Exposition of 1900 demonstrated the entire practicability of the system, and the enormous capacity of such a continuous means of transport was there especially made clear. The continuity of the movement renders the device capable of absorbing the flow of people as rapidly as they present themselves, and local crowding at any point can be at once relieved by a few steps, without delay. The serious proposition to introduce such a travelling platform in a subway under the Grands Boulevards in Paris is another indication of the appreciation of the system. There is little doubt that the true remedy for local congestion in cities is to be found in the use of continuously moving means of transport, even if over short distances only, the essential feature being the avoidance of stoppage in the contracted section.

An interesting landmark of industrial and engineering progress of current importance is the Düsseldorf Exposition, which was most successfully opened on May 1. Successful is, indeed, the word to apply to the opening of the exposition, since the grounds, buildings, and exhibits were ready on the opening day — a marked exception to the opening days of previous expositions, so far as the records go. Being devoted to the Rhenish-Westphalian industries, the display is largely metallurgical, the iron and steel works of Rhenish Prussia being most conspicuous. The latest developments in the generation and application of steam power are shown; including the use of superheated steam, central condensation, and direct-connected electric generating sets. Electric and hydraulic driving are conspicuous, and the products of such establishments as Krupp's, the Gutehoffnungshütte, the Bochum Works, and others are prominent.

Expositions are always considered as important educational influences, and this is especially true as regards scientific education. The entire matter of technical education is acquiring much prominence at the present time in connection with the development of engineering progress. In Great Britain, especially, agitation is being made for more thorough practical training as a necessity to enable England to maintain her industrial position. In this connection the development of the mechanical laboratory as a means of training and research is noteworthy. The practical study of mathematics is also being constantly urged, as contrasted with the scholastic methods generally in vogue; and the discussion by Dr. Perry at the recent meeting of the British Association has attracted special attention.

The necessity for .the establishment of bureaus of standards is now fully admitted; and the recent opening of the bureau at Washington renders it probable that ultimately there will be in the United States an equipment and force comparable with that of the International Bureau of Weights and Measures at Breteuil. The work of MM. Benoit and Guillaume, at the latter place, upon the determination of the true values of the metre and the kilogramme, is an excellent example of the value and importance of such establishments.

The recent attempts to procure additional legislation in connection with the introduction of the metric system into the United States calls attention at this time to the system itself. The authority of Congress to compel the adoption of any system by the public has been questioned; but it is now clearly understood that the present effort is to render the use of the system compulsory for government work only. Even in this matter the surveys of government lands are excepted, which in itself is a frank admission of unwillingness to make a change when it involves any serious disturbance of records and boundaries. The popularity of the metric system appears to be mainly confined to students, professors, laboratory workers, computers, and those whose relation to the commercial and manufacturing questions is more or less remote. The great engineering establishments have in their gauges, templates, standards, and dies, a capital not unlike the stored labor involved in the government surveys of public lands; and the same arguments which permit the exclusion of the Land Office from metric legislation might well be applied to the great industrial establishments of the country. If the engineering progress of the United States continues, it does not follow that she should adopt the metric system just because France, Germany, and a number of small countries of no engineering importance have done so. The technical preponderance of the English-speaking race will enable it to carry with it to all parts of the industrial world, without special legislation, any system of metrology it may see fit to devise; and there is no reason why American and English engineers should not decide upon a system suitable to existing methods while free from their inconveniences, and deliberately overrule the attempts to force the metric system into American workshops.

With the general use of automatic machinery, and with the enactment of employers' liability legislation, there has come renewed attention to devices for the prevention of accidents to workmen. In many instances this has led to modifications in the original designs; gear wheels being enclosed in casings and moving parts protected as far as practicable. The use of electric driving has permitted gearing, belting, and shafting to be avoided to a great extent, and has thus removed a frequent source of danger. Indeed, there is little doubt that the dangers from electric transmission are less serious than those of the mechanical forms of transmission which they replace.

The subject of the electrical transmission of power continues to attract attention; and, in locations in which the high cost of fuel warrants, long-distance transmissions have been installed for regular service over more than 100 miles from the hydro-electric generating station. Pressures as high as 50,000 volts have been installed with success, and on the Snoqualmie Falls plant the transmission to Seattle and Tacoma has been operated over 153 miles with a transmission loss of a little more than thirteen per cent.

An interesting feature in connection with engineering work is the close study which is being given to the behavior of materials of construction under stress. The study of the physical properties of metals and alloys by the examination of etched sections under the microscope has led to important knowledge of the effects of heat treatment; the variations observed in materials of the same chemical composition being shown to be associated with differences in physical structure. The action of stress upon materials has been recently made the subject of study by using glass as the material and examining the interior by means of polarized light; the internal stresses becoming visible as to character and direction in a very interesting manner. Since the internal distribution of stresses has been shown to be independent of the material, these experiments with glass enable the laws of the resistance of materials to be studied generally by experiment, permitting the deductions of theory to be put to the test very effectively. The experiments upon beams and pillars of glass have confirmed in a general way the accepted theories, but have also shown that certain elements, hitherto considered negligible, should be taken into account.

Recent progress in wireless telegraphy, or, as Professor Lodge prefers to call it, "space telegraphy," has been limited mainly to the matter of "tuning" the receivers, so as to permit the exclusive transmission of messages, as well as to prevent the confusion arising from interference. Although much is claimed in this direction, the details have not been made public to an extent sufficient to permit discussion to be made; but a certain degree of practical success appears to have been attained.

While there is no great reason to assume that the Marconi system can supersede submarine cables for general commercial work, there are certain applications to which it is immediately applicable. Thus, the commencement of installations for communication with the interior of Alaska and the Klondike will permit telegraphy over a country in which the difficulty of maintaining overhead wires has thus far been prohibitory. Success in that country will doubtless mean the establishment of stations along the Peninsula and the Aleutian Islands to Asia, so that the Pacific cable may find itself second in the field so far as actual communication is concerned.

HENRY HARRISON SUPLEE.

THE AMERICAN DRAMA.

It is no secret that the drama in America is in a parlous state. The voices of protest have long been heard. On the one hand are the veterans who chant the praises of the epoch that is closed. For modern plays and writers they have scant tolerance or open contempt; but they wax eloquent over the memories of ancient stock companies, such as those of the Boston Museum and Wallack's Theatre in New York, and of the stars of the elder day who interpreted the great Shaksperean parts — Fechter, Salvini, Booth, Charlotte Cushman, and Adelaide Neilson. These are the prophets of despair. On the other hand are the devotees of the modern literary dramatists — Ibsen, Sudermann, Hauptmann, Maeterlinck, Tolstoi, and Echegaray. They have little to say of actors, past or present, and they are likely to think in their hearts that Ibsen is greater than Shakspere. But they have much to say of elevating the drama. From time to time they have organized theatres in imitation of the independent theatres of Paris and London. Except for the somewhat dreary nature of the plays they champion, they might be called the prophets of hope. Over against both of these are the scribes of the present, who, because they are of the present, know neither hope nor despair. They write for the great theatre-going public; in fact, they are the great theatre-going public.

According to the orthography of the great theatre-going public, Shakspere spells ruin and Ibsen spells rot. When Miss Maude Adams plays Juliet, it laments that the part does not give full scope to her piquant and winsome personality, or it praises what it calls her interpretation as original. When Mr. William Gillette announces that he is to play Hamlet, it observes, with a mingling of jest and earnest, that he will probably not be able as usual to make the action of the play revolve about his cigar. If it regards the efforts of those who have tried to elevate the stage, it is only to remark with a grin that their elevator broke. It has no real appreciation of drama as drama, and as a result it is easily caught by sensational advertising or by the lure of luxurious scenery. It finds no essential difference, for example, between a recent spec-