

Fig. 4.—End-dumping Coal Truck of English Make.

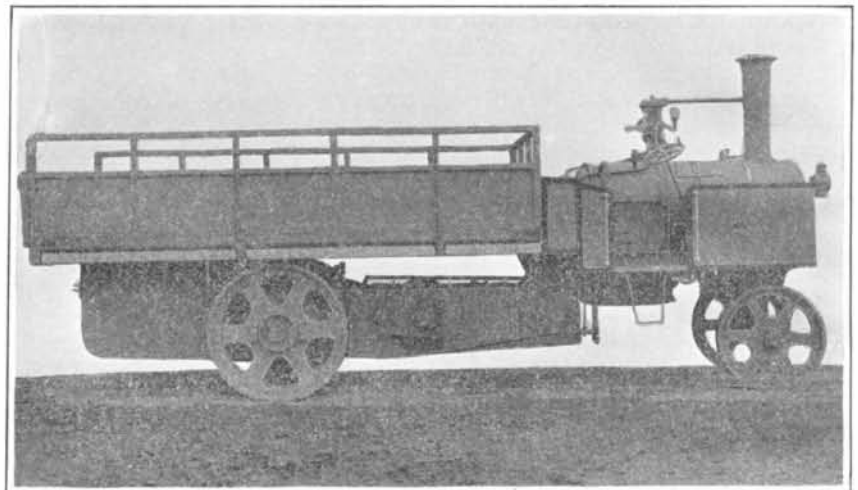


Fig. 5.—A Seven-ton Steam-propelled Coal Truck.

yards, making a round trip distance of two miles—the length of the working day was 10 hours. The truck was loaded at the yards from a clam-shell loading device in from 4 to 10 minutes and the road time for the round trip averaged 20 minutes. This is a slow rate of speed, being only six miles per hour, owing to the fact that the delivery was made over a steep grade and through badly congested streets. The average load carried was 11,240 pounds of slack, and the average trip with loading and unloading consumed 40 minutes. Fifteen trips were

made during the day and a total of over 84 tons was delivered to the customer's bins.

Comparing this work of the motor truck with the work of a horse-drawn truck on the same day and on the same job, one team of horses made 8 trips during the 10-hour day and, with a modern dump wagon, carried an average load of 7,300 pounds and a total tonnage for the day of 29 tons against the 15 trips per day made by the motor truck carrying an average load of 11,240 pounds and a total tonnage for the day of 84 tons. It is necessary for

the company to keep a number of snatch teams on the hill near their yards to assist all horse-drawn trucks in making the grade. The dump truck takes this hill on low speed with ease. It is estimated that the use of these snatch teams adds 2½ cents per ton to the cost of cartage. These figures show that even on short hauls against adverse conditions, a 5-ton dump truck is doing the work of three horse-drawn trucks and saving the extra service of snatch teams on the hill, which are required by the horse-drawn trucks.

## Recent Development of the Locomotive—II\*

### The Latest Stages in Its Evolution

By George R. Henderson

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 1931, page 9, January 4, 1913

#### ADJUNCTS AND DETAILS.

It is probably true that cast steel is more closely connected with the development of the large locomotive than any other single item entering into locomotive construction, and the possibility of being able to get large castings in this material has proved a very important factor in the advancement of this proposition. Some years ago steel castings were produced only in very small sizes by means of crucible furnaces, and such things as steel driving wheels, frames, foot-plates, etc., were unknown. With the large number of open-hearth steel plants making steel castings of high-grade material now in this country, there has been a great impetus given to the reduction of weight and increase of strength by substituting steel castings for iron castings and, in many cases, for iron forgings. In the former category probably driving wheel centers have been the most conspicuous examples, as even ten or fifteen years ago the axles and crankpins of locomotives were assuming such proportions that it made it difficult to obtain the proper strength with an iron casting. As the main driving wheel is subjected to a far greater stress than the other driving wheels, steel was first substituted in the main driving wheel only, but nowadays, when it is desirable to get the boiler as large as possible and thereby keep the other parts as light as possible, cast steel is used in many cases in all the wheels of a locomotive. It has now even become difficult to get along with cast steel, as, with the increased size of axles and pins and the inadvisability of increasing the stroke, we have gotten to such a point where there remains only 5 inches or 6 inches of metal between the axle and the pin fits, and when we consider that these are forced in with pressures from 100 to 200 tons it will be understood how difficult it is to produce a steel casting that will satisfactorily withstand forcing stresses and also those due to operation.

At first there was much difficulty in making driving wheels, as the rim would set in the mold long before the hub and fractured spokes would occur. This was overcome by separating the rim into sections so that the spokes could pull the rim toward the center as cooling progressed. Later, however, the steel works found that they could cast these rims solid by uncovering the hub and arranging to cool that portion more rapidly so as to promote uniform contraction throughout the casting.

Foot-plates have been another very important example of the use of steel instead of iron castings. In olden times the foot-plate was often made unusually massive in order to add adhesive weight to the engine, but the great desire to produce boilers of maximum capacity has led to the use of foot-plates of cast steel, thereby reducing the weight very materially and allowing for greater boiler capacity. In such castings as these the weight of the piece in steel would be anywhere from one half to one third of what it

would be in cast iron, and when this practice is followed through the different parts of the engine the great saving of weight is at once apparent.

Boiler supports, guide yokes, frame separators, and in the Mallet type of locomotive, saddles connecting the

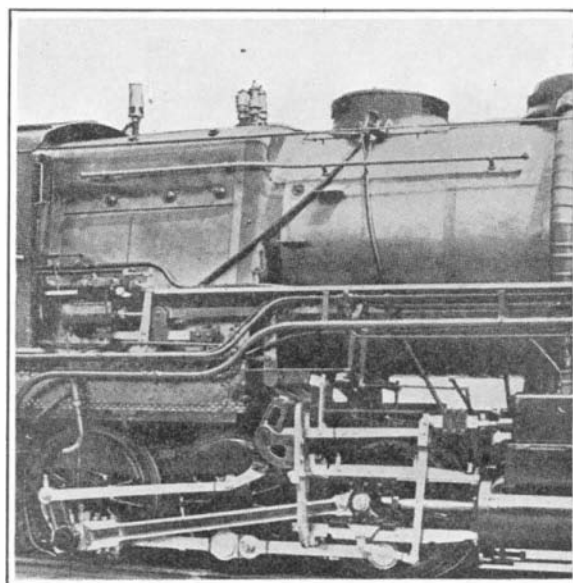


Fig. 7.—Power Reverse Gear.

frames and the cylinders, are now made of steel castings, and this metal is very much superior to iron in standing impact and even the effects of an unexpected collision.

In the replacement of forgings, cast steel has also rendered an important service; the most notable example of this is in locomotive frames. For years these were made of iron worked under the steam hammer, and, as the frames were of large sections, it was very difficult to properly weld the pedestals and braces together. When the sections were not over 4 inches in thickness there was little difficulty, but even then it was found that the welds, in spite of the best care, had often been imperfectly formed and would in service pull apart. With 5-inch frames, which are now common, and 6-inch frames, which are being introduced, this work would be very difficult, but cast steel permits the use of a section of almost any size. Then, too, the braces and all the parts are cast in one solid piece, so that there is less fitting and less opportunity for parts to become loose and work upon each other when the engine is in operation. Many of the more complicated forgings, such as equalizer beams, frame braces, and parts that have been made in the blacksmith shop, are now constructed of cast steel, often reducing the weight and at the same time the cost of manufacture.

In this country open-hearth steel is used almost exclusively for this material, but in Europe Bessemer steel with a comparatively high phosphorus content is much in vogue. This makes a smoother casting, as the phosphorus adds to the fluidity of the metal when being poured, but Americans are rather opposed to the use of Bessemer steel in important structures on account of its known liability to segregation and to crack under sudden strains. The open-hearth steel used for locomotive castings is both acid and basic, the former, of course, requiring a higher grade of pig to be used in its production. The great difficulty with steel castings at the present time is the tendency for piping and blow-holes to diminish the strength of a section at some part where it is impossible of detection before rupture, and, while this difficulty is being gradually reduced, largely by the careful study of proper design and the introduction of large sinking heads in molding, yet it must still be contended with and prevents us from using as high a fiber stress as we should if we could get rid of these objectionable features. Such steel has a tensile strength of from 60,000 to 80,000 pounds, which is fully double what can be obtained from cast iron, and, on account of its ductility and resistance to stand blows, it is superior to cast iron in even greater proportions than its increase in strength.

As yet little has been done in the use of cast steel cylinders in locomotives, although some few have been in service. As there is a tendency toward three-part cylinders—that is, a central saddle with a separate cylinder bolted at each side—the feasibility of using steel cylinders has been greatly enhanced. Of course, such cylinders have bushings of cast iron for both the piston and the valve, and, as the latter is nearly always of the piston type, the construction of a cylinder of cast steel is not especially difficult. The recent practice of using outside steam pipes materially assists in this problem.

Following the introduction of steel castings for frames, driving wheels, driving boxes, etc., alloy steel has also made its appearance in locomotive construction, and chrome vanadium or chrome titanium is frequently possible for the parts involving heavy stresses. The latter adds very little to the cost of steel per ton, and is thought by some to be practically as efficient as the high-priced vanadium steel. Nevertheless, there is difficulty being experienced, with both of these alloys, and when we consider that even the heaviest sections that we are able to produce now are hardly strong enough to stand such enormous piston loads, which in some cases reach to 140,000 or 150,000 pounds, the necessity for refinement in this line is apparent.

There has been little attempt to make such parts as connecting rods, parallel rods, etc., of steel castings, and the few attempts that have been made in this line have not been crowned with sufficient success to warrant extension in these particular details. Crank axles are seldom used in this country, but it has been found that the

\*Paper read before the Franklin Institute and published in its Journal.

crank-webs in a built-up axle have given very good service when made of cast steel, but the forces in such a structure produce, principally, bending and torsion where steel castings are particularly satisfactory. In connecting rods, however, there is so much tension and compression that it does not seem wise to run the risk of using a metal that may have a blow-hole or pipe at some critical part, and only high-grade hammered steel is used, as a rule, in these forgings.

While the Walschaerts valve motion has been recognized for many years as a suitable means for operating the valves on a locomotive, and has been used largely in Europe, it is only recently that its application to locomotives in this country has been worked out on a large scale. There have been many essays written upon the relative advantages of the Stephenson, which has been universally used, and the Walschaerts valve motion, so far as the movement of the valve itself is concerned, some claiming the Walschaerts gear with its constant lead was a great benefit, while others claim that the Stephenson motion with its increasing lead of early cut-offs is most desirable. Personally, we are inclined to agree with the latter theory. It is well known that a locomotive with a large amount of lead is very slow in starting, whereas one with a small or blind lead will be particularly active in getting under way and being reversed. With the constant lead of the Walschaerts motion it is necessary to settle upon some amount that will be satisfactory under ordinary running conditions, and this often produces a locomotive that is noticeably tardy in handling. In the Stephenson motion it is perfectly feasible, if desired, to set the valves line and line when the reverse lever is in the corner and have from  $\frac{1}{4}$  inch to  $\frac{3}{8}$  inches lead when working at early cut-offs. This in itself constitutes a considerable advantage, however, it has been found by practical demonstration in road tests that there is no essential difference in either fuel economy or economy of train operation between the two methods of distribution, and for all practical purposes we can generally assume that the steam distribution and economy will be the same in both.

What, then, has given the impetus to the Walschaerts gear within the last decade, if there is no advantage to the valve movement, and, in fact, the possibility of a disadvantage? The answer is that it is simply caused by structural reasons. The Stephenson motion, with its inside links, while being well protected from damage by a side-swipe, has the disadvantage of requiring eccentrics, which, with the modern proportions of driving axles, have assumed very large dimensions, so large, in fact, that there is continual trouble in trying to keep them lubricated, as the weight and speed of the running surfaces have been increased with the enlargement of the axles. There is also considerable difficulty in suspending the link centrally, and, while it could be done, it was rather a troublesome and expensive arrangement. Perhaps the greatest incentive to remove the valve motion from under the barrel of the boiler was the fact that the heavy engines with long frames require cross-bracing, and when the eccentrics and rods are removed we have splendid opportunities for connecting together the frames with ample cross-braces. The increased weights have called for wider frames and long journals, so that there is very little space left in which to place a satisfactory inside link motion.

The Walschaerts gear overcomes both of these difficulties permitting not only a very comprehensive system of cross-bracing, if desired, but also eliminates the eccentrics and places the motion where it is very accessible. It has been claimed that the Walschaerts valve gear has fewer pieces and weighs less than the Stephenson, but when we consider the supports necessary to carry and suspend the various parts of the Walschaerts gear there is a great deal of weight and expense which, while it is not a part directly of the valve gear, yet is necessary to support the same. This results in an increased cost for the Walschaerts as compared with the Stephenson valve gear. In many cases these supports can be worked in as part of or an extension of the cross-bracing of the frames and boiler and produce a very simple and strong structure, and, taking everything into consideration, the change in valve gear has resulted in a very much better braced engine than was possible with the old Stephenson motion. There is no question, therefore, but that this valve motion is here to stay, in spite of the fact that many people consider the actual movement of the valve not as satisfactory as with the Stephenson arrangement.

With the large and heavy valves that must be moved in the modern locomotive the force necessary to operate the reverse lever has considerably increased. With articulated locomotives, which have two or more shifting valve motions, the work to be done is doubled or trebled; therefore, we are prepared to understand the second advent of power-reversing gears. It has probably been thirty years since the first steam reversing gear was used in this country, after a few years' use of which on a very small number of locomotives it was abandoned. In those days the valves were small and there was no difficulty in handling them very satisfactorily with the reversing lever. Now, however, the conditions are entirely differ-

ent, and, in addition to the heavy weights to be moved, the wide fire-box prevents in many cases a good practical application of the time-honored reverse lever. In some cases it has been necessary to use a power reverse simply because a satisfactory hand reverse lever could not be worked in with the type of boiler used. These considerations are of sufficient importance to necessitate the complication of the power reverse gear, so that it is not likely that it will be relegated to oblivion, as was the attempt made many years ago.

There are several types of power-reversing gears, but we believe that the type in which the movements of the engineer resemble those of the ordinary reverse lever are most desirable, particularly when engines are placed in the chain gang and are not operated with a single crew. Thus, in the reversing gear which is illustrated by Fig. 7, the engineer simply pushes a small lever to the desired position and the reversing engine automatically moves the valve motion until it has assumed a position corresponding to the hand lever, and, while this hand lever may be reversed with a very rapid movement, yet the engine itself will pull the motion back slowly but surely, regardless of the speed with which the engineer has moved the controlling lever.

While piston valves have long been used in marine engineering, the general use of them in locomotives dates back a little more than ten years. The Vaucrain compound locomotive with the high and low-pressure cylinders superimposed, one above the other, was operated by a single piston valve for the two cylinders, this reducing the mechanism to a much simpler form than could be accomplished by means of slide valves. Previous to this there had been very few engines of the simple type equipped with piston valves, but the success which attended the use of the piston valve with the Vaucrain compound induced its extension upon locomotives operated by single expansion only.

When the piston valve is used to replace an ordinary slide valve it is of a very simple type, and is practically a slide valve extended into a circle, with packing rings used at the several steam and exhaust edges. There has been considerable discussion as to the value of these valves as compared with slide valves, and a number of tests have been made, some showing better for one, some showing more economy for the other. There is little doubt but what this question of economy depends greatly upon the maintenance of the valve and the condition in which it is allowed to run, as a leaky valve of either type would, of course, be very wasteful of steam.

One of the principal advantages of the piston valve is the fact that it is fully balanced and easier to manipulate the engine than with a slide valve, even of the balanced type. As a matter of fact, piston valves are generally manipulated with greater ease when the throttle is open than when it is closed; still, the converse is true of balanced slide valves.

In spite of the fact that there is some doubt as to whether the piston valve is really more economical in steam consumption than the slide valve, yet they have been introduced in great numbers, partly due, no doubt, to the fact that the large cylinders require large ports, and the port opening with the piston valve can be made nearly double that possible with an ordinary slide valve. The large valves also are very little harder to handle in the cab than those of smaller diameter. Another advantage lies in the fact that piston valves can be, and generally are, so designed that the steam enters at the center, or central admission, as it is called, and exhausts into the ends of the chamber, the valve being hollow, permitting both ends of the steam chest or valve chamber to be in communication with each other. This reduces the pressure on the valve stem packing to that of exhaust steam only, and when it is considered that the variable travel of the valve makes it much more difficult to maintain packing on the valve rod than on the piston rod, which travels the same distance and forms no intermediate shoulders, the advantage in relieving this packing of high pressure steam will be at once appreciated.

Reference was made above to the fact that in the Vaucrain compound of the superimposed cylinder type one valve was able to regulate the admission of steam to both cylinders. In this case both the pistons worked together, being attached to the same crosshead. A later type of the balanced compound, in which the pistons move in opposite directions, has also been successfully worked by one valve, resulting in extremely simple mechanism for this type of engine.

The advantages of the Allen ported slide valve for the quicker admission of steam to the cylinders has long been appreciated, but this has not been generally introduced into piston valves, one reason, no doubt, being due to the fact that the much larger valve opening, on account of the greater length of port, made it unnecessary. With the increasing size of cylinders and the greater speeds at which it is desired to operate large tractive forces, it becomes necessary to adopt a somewhat similar arrangement for piston valves. This has been developed into the doubled ported piston valve, whereby there are two ports or openings, both for steam and for exhaust. The

advantage of this is that a higher steam line or pressure line can be maintained in the cylinder up to the point of cut-off and less back pressure during the period of exhaust, as the steam has twice the area of opening when near the points of port opening and closure than could be obtained with an ordinary valve of the same size. As this port is placed partially in the valve chamber bushing, there is little additional complication added, except in making the valve itself, but the cylinder casting can be molded as easily in one case as in the other. While this is a very recent development, yet it promises such good results that we believe its quite general adoption is likely to be only a question of a short time.

While the boilers of locomotives have increased enormously in size, there has been little change in the actual design and construction. Of course, the larger diameters have given occasion for the introduction of thicker sheets and for joints of increased efficiency. The old double-riveted lap joint, which had an efficiency of about 70 per cent, has been superseded almost universally by the butt joint, with an efficiency of from 80 to 90 per cent. Besides reducing the thickness of the shell sheet, the butt joint pulls centrally and removes the cause of grooving, which was so often found when boilers were provided with lap joints, no matter how strongly they might be riveted. This grooving was due to the eccentric pull of the two sheets on the joints, and has been largely responsible for shell ruptures. It is, moreover, difficult to see before trouble ensues, but it reduces the section of the plate by starting a fracture at the caulking edge of the inside lap. The butt joint which has generally been introduced has a wide inside and a narrow outside cover plate, but in some cases the diamond joint has been introduced, which makes a very stiff shell at the joint. Seams have been welded, not only at the ends but sometimes for the whole width of the sheet, but, as a rule, a cover plate is put on in addition to the weld, so as not to depend entirely upon the welded joint. There are different ways of making these welds, sometimes by means of direct flame or fire, sometimes with an electric arc, and sometimes with acetylene, the latter coming now into more general use as the apparatus is portable and does not require connection with any source of power to provide current.

Cast metals have almost entirely disappeared from boiler construction, whereas in former times, with low pressures, it was considered permissible to use cast-iron dome rings and dome caps, yet these are now invariably made of pressed steel. The complete dome is sometimes pressed out of a single sheet of metal.

The fire-box itself has been affected principally by the introduction of flexible staybolts. These are generally of two types, one with a spherical end encased in a cup screwed into the sheet, of which the Tate is perhaps the best illustration, and another one consists of a hinged bolt, of which the "Breakless" is the best known example. These were introduced to reduce the great number of breakages which some lines experience, particularly in the corners or ends of the fire-box. Some roads even go so far as to specify that all of the fire-box staybolts shall be of the flexible type, while the majority of roads are satisfied to put in only 300 or 400 of such special bolts. These bolts add about 50 cents each to the cost of a locomotive, and the question has recently been raised as to whether they are really giving the immunity from breakage, which has been contended. The staybolt problem is rather a difficult question, inasmuch as if we make the bolt larger in diameter it will be stiffer and still less likely to stand transverse strain. With increasing pressures we cannot well make them thinner without reducing the spacing, and this is undesirable on account of the likelihood of the water space being choked up with mud. Then, staybolts are likely, if overheated, to let the crown sheet drop, and for this reason it is good practice to use button-headed bolts for the central rows of the crown sheet stays. The wide fire-boxes have long caused the practical disappearance of crown bars, so that there are practically either radial-stayed or Belpaire type of boilers in general construction at the present time. With the Belpaire the crown sheet is naturally level, but with the radial-stayed the high portion which would be first to be uncovered by low water is often protected by button-headed bolts. Some, however, think this a disadvantage and would prefer that a short section of the crown sheet should let go and relieve the pressure without pulling down the whole crown sheet. Records of locomotive boiler explosions, including dropped crown sheets, seem to indicate that less than 2 per cent are due to deficient strength, and that practically all of the disasters are caused by low water, either through the negligence of the engineman or some difficulty with the water feeding or indicating devices.

In recent years the Jacobs-Schupert fire-box has been introduced as practically indestructible with even extraordinarily careless treatment in connection with fire and water. This boiler is composed of sections riveted to diaphragm sheets, so that no staybolt is used in the construction of the boiler, and some remarkable results of tests have indicated that it is very difficult, if not impossible, to cause a disaster by means of low water, even

with a hot fire in the fire-box. Of course, this fire-box is more expensive to construct, and it is questionable whether the railroads would feel it necessary to pay this increased cost as an insurance against such troubles.

The inside of the fire-box is occasionally provided with arches of various types; some of these rest on tubes and some on studs, some are made of solid bricks, and some are of hollow bricks with openings through the front water leg to introduce air for combustion. Some tests recently made showed that there was little, if any, efficiency or economy afforded by means of jets of air brought in through the arch brick, and the greater expense of the

brick and the difficulty of maintaining them would seem to give preference to a solid brick, particularly if there was no gain over the hollow tiles. However, these questions of combustion have been so much discussed and disputed, and as results of different tests are likely to show such a variety of results, it is doubtful whether the question of the value of the brick arch and its various forms for admitting hot air, etc., will ever be satisfactorily settled in any one way to the community at large. Most people agree that the brick arch has a very positive value in connection with smoke abatement and fuel economy; yet in some sections of the country where the

flues need frequent rolling and beading it is almost impossible to maintain an arch for any length of time, and it often prevents the quick turning of a locomotive, as the man cannot get in the fire-box or remove the arch until it has become sufficiently cooled. These practical considerations are often much more important in a locomotive than the mere theoretical consideration of fuel economy, as the business of moving trains is of primary importance, and anything that increases the round-house work or detains the locomotive at a terminal is bound to give way to the urgencies of transportation.

To be continued.

# Diffusion of Education and Knowledge\*

## Illiteracy and Literary Productiveness in Different Countries

By Arthur Macdonald

THE educational status of a nation consists in the amount of literacy, number of teachers, and number of persons in its primary and secondary schools, and in its colleges and universities, relative to population. The status of knowledge may be indicated by the number of books, periodicals, and newspapers relative to population. This knowledge may take two forms, one gained through books, the other through periodicals, and newspapers.

lishes the largest number of books, but not relative to its population. Denmark issues the largest number of books in proportion to its population. The United States, compared with European nations, is next to highest (Switzerland) in number of newspapers issued, but next to lowest (Russia) in number of university students enrolled and books produced, relative to population.

correspondence fails in the case of Denmark, which is behind France, Great Britain, and the Netherlands. There is no further correspondence of these three highly literate countries in the other educational columns.

In brief, there appears to be but little necessary relation in these countries between degrees of education and amount of literary production. Thus, Italy, with its great illiteracy, stands very high in university education. This is interesting in connection with the fact that Italy is doing some of the best work in sociology, which is suggestive in connection with the further fact that she stands next to the highest in production of sociological works.

The United States has a large percentage of illiteracy, yet ranks highest in percentage of population enrolled in schools, but has the smallest number of university students. It has next to the largest number of newspapers, but produces next to the smallest number of books. Russia, about which data are more difficult to obtain, stands lowest in all respects relative to its population.

Different countries naturally do not classify books in the same way, and sometimes one country will include under one head publications that other nations would place under another subject, and hence results given in Table II must be taken in a general way.

In order to render the table more trustworthy, we have included two or more subjects under one head. For instance, under "History," both "Biography" and "Geography;" under "Literature," "Poetry," "Fiction," and "Drama," and under "Religion," "Theology."

A few headings could not be classified nor combined with others and were omitted, so that the table is not complete, but the percentage for each subject given is, of course, not affected.

It may be interesting to note the kind of books some countries prefer, as shown in Table II. Thus, France publishes relatively more medical works (10.5) than any other nation here mentioned. Italy is second (7.6) and Germany third (5.8) in this subject. Belgium publishes relatively the most law books, Denmark the fewest. United States, Denmark and Germany lead in religious works. Denmark and France excel in literature, and Germany and Italy in educational work, and France in books on military science.

Although correspondence between mental and pathological conditions, or concomitant relations, does not necessarily indicate causal connection, yet it is interesting to note a few instances. In general, those countries which have the greatest illiteracy, as Italy, Belgium, and France, show the highest percentage of murder. They also have a high percentage of still-births, death-rate, and death-rate under one year of age. Two of these countries, where the illiteracy is more pronounced, as in Italy and Belgium show a low rate of suicide and divorce. On the other hand, the least illiterate countries, as Germany, Switzerland, and Denmark, have a high rate of suicides.

**Auto-sleighs for Russia.**—There is a good field for automobile sleighs in Russia, and in order to promote the use of this mode of locomotion there is to be held an international concourse of motor sleighs during the latter part of January. It is organized by the Imperial Russian Automobile Club and will take place at St. Petersburg. The trials will be held upon one of the branches of the Neva which will give a good surface of ice or snow, and also on the roads of Krestowsky Island. Runs of 3 miles are to be made upon the road and 2 miles upon soft snow, and the motor sleighs are expected to show their usefulness in places where automobiles cannot run. Commemorative gold medals will be awarded to the winners of all the contests and silver medals for success in single trials, and there will also be a special cup awarded for a speed race.

TABLE I.

Country 1908	Education					Knowledge and information			
	Number of illiterates per 10,000 recruits	Per cent. of population enrolled in schools	Number of university students per 10,000 population	Number of newspapers per million population	Number of books published per 100,000 population	Smithsonian list: Number of publications per million population (1904)	Number of books published	Number of newspapers and periodicals issued (year)	Smithsonian list: Number of publications (1904)
Column	1	2	3	4	5	6	7	8	9
Belgium ...	833 <sup>1</sup>	12.2	68	27	28	48	2763	209 (1908)	354
Denmark ...	20 <sup>2</sup>	13.0	—	84	135	42	3519	220 (1908)	112
France ...	346 <sup>1</sup>	14.2	81	251	28	42	8799	9877 (1908)	1723
Germany...	4 <sup>1</sup>	17.0	65	115	49	39	33317	7000 (1907)	2390
Great Britain and Ireland	100 <sup>1</sup>	17.0	56	98	22	45	9821	4400 (1905)	2038
Italy ...	3072 <sup>3</sup>	8.1	77	60	21	24	6918	2067 (1904)	834
Netherlands ...	210	15.0	72	132	56	36	3258	760 (1906)	207
Russia ...	6110 <sup>4</sup>	4.5 <sup>5</sup>	16	8	—	3	23852	2229 (1905)	515
Switzerland ...	9	18.6	178	275	116	90	4256	1005 (1907)	351
United States...	380 <sup>6</sup>	19.7	20	260	10	—	9254	21320 (1908)	—

<sup>1</sup> 1904. <sup>2</sup> 1897. <sup>3</sup> 1903. <sup>4</sup> 1895. <sup>5</sup> 1907: in 1907, 39 per cent. of males and 27 per cent. of all persons (9 years of age and more) were able to read. <sup>6</sup> In white male population 21 to 24 years of age in 1900.

TABLE II.—Book Production—Per Cent. for Each Subject.

Country 1908	Medicine	Law	Philosophy	Religion	History	Sociology	Literature	Educational	Art	Science	Military science	Fiction
Belgium ...	5.7	7.0	2.6	3.8	13.4	8.6	17.3	3.8	6.2	7.0	1.1	—
Denmark ...	3.7	1.1	1.2	9.6	—	—	23.2	3.3	2.2	9.7	—	—
France ...	10.5	6.3	2.1	7.3	17.3	6.4	22.0	11.4	1.2	4.5	3.9	—
Germany...	5.8	10.0 <sup>1</sup>	2.3	8.4	9.0	10.0 <sup>1</sup>	19.5	13.8	2.9	5.7	2.3	13.7 <sup>4</sup>
United Kingdom	3.1	2.6	—	9.5 <sup>2</sup>	13.9	6.7	18.4	6.4	—	11.8	—	2.6
Italy ...	7.6	4.9	2.8	4.4	12.0	6.7	14.1	13.1	2.6	5.8 <sup>3</sup>	1.9	6.3
Netherlands ...	3.3	5.3	—	6.2	—	5.3	—	9.3	—	5.3 <sup>3</sup>	—	—
Russia ...	4.6	3.1	—	6.8	3.0	—	10.2	7.9	—	2.5	—	—
United States...	3.6	9.9	1.9	8.8	14.7	5.9	13.3	4.5	2.5	5.1	—	16.0

<sup>1</sup> Law and political science. <sup>2</sup> Religion and philosophy. <sup>3</sup> Science and technology. <sup>4</sup> Belles lettres.

One is knowledge in general; the other consists more in current information.

The question may be asked, if a community or country leads another in literacy, diffusion of education and knowledge; if, relative to its population, it has more pupils in school, more teachers, more students in colleges and universities, more books in its libraries to read, and more periodicals and newspapers to peruse, is not this country or community, as a whole, very probably better educated and more intelligent than the other country or community? While there are exceptions due to special conditions, we are disposed to answer this question in the affirmative.

Table I indicates in a general way the diffusion of education and knowledge in some leading countries.

Column 1 gives the relative amount of illiteracy among army and navy recruits. As these are mostly adults, they probably represent best the real amount of illiteracy. Column 6 gives the number of publications (relative to population) in the list of the Smithsonian Institution in Washington. These publications are of the highest class, including journals issued by learned societies and governmental institutions.

Examining Table I it will be seen that Switzerland is much in advance of all the other countries in general diffusion of education and knowledge, and Russia is last. Italy also is very low in these respects. France shows a high degree (next to Switzerland) of diffusion in university education (81) and newspaper information (251). Germany shows the lowest degree of illiteracy and pub-

Since we are disposed often to estimate countries as to their mental status or literary production without reference to their population, we will compare the countries in Table I according to the absolute number of books, periodicals, and newspapers published, as given in columns 7, 8 and 9.

As to largest number of books the rank is Germany, Russia, Great Britain, United States, France, Italy, Switzerland, etc.

As to number of newspapers and periodicals, United States is unique, publishing twice as many as France (next in rank), and from three to ten times as many as some of the other countries.

As to the Smithsonian list of publications, the rank is Germany, Great Britain, France, Italy, Russia, Belgium, Switzerland, etc.

If we take the extremely illiterate countries, as Russia, Italy, and Belgium, we find a correspondingly low percentage of the population enrolled in the public schools and a relatively low percentage of newspapers published. But when we come to the number of university students enrolled, the correspondence fails as to Italy and Belgium, which have, relative to population, a larger number of university students than Germany or Great Britain. As to the number of books published relative to population, the correspondence fails in the case of Belgium, which produces as many books as France (column 5), relative to its population. As to the Smithsonian list of publications, the correspondence fails in the case of Belgium, which is next to the highest (column 6).

If, now, the countries distinctly the least illiterate, as Germany, Switzerland, and Denmark, are compared in respect to enrolment in schools or primary education, the

\* From a paper on "Mentality of Nations in Connection with Patho-Social Conditions," in *The Open Court*.