

Swedish. Jettel considers that it should not exceed the half of the proportion as given above.

The composition of the friction-surface is :—

Glue,	1½ parts.
Umber,	1 part.
Manganese,	4½ parts.
Sulphuret of antimony,	16½ "
Amorphous phosphorus,	10 "

Gentele has subsequently examined the composition of Swedish matches, and obtained very different results. He found:—

Chlorate of potash,	32 parts.
Bichromate of potash,	12 "
Red lead,	32 "
Sulphuret of antimony,	24 "

This mixture ignited readily upon a surface consisting of 8 parts amorphous phosphorus, with 9 parts of sulphuret of antimony.¹

It appears from the experiments of Gentele, that slight differences in the mixtures, have little effect upon the quality of the matches, if only the preparation has been careful, *i. e.*, if the separate ingredients have been ground as finely as possible, and intimately mixed, which applies also to phosphorus matches, and to all similar mixtures. The selection and preparation of the wood are not a matter of indifference.

(To be continued.)

THE "CAMEL" ENGINE OF ROSS WINANS.

By J. SNOWDEN BELL.

There are two American locomotives that have become historic from having given origin and name to the two classes of engines which have, to a greater extent than any others, contributed to the development and economization of railroad freight transportation. These are the "Camel," built by Ross Winans, of Baltimore, in June, 1848, for the Baltimore and Ohio Railroad, and the "Consolidation," which M. W. Baldwin & Co., of Philadelphia, constructed for the Lehigh Valley Railroad, in July, 1866. The performance of the latter was found to be so satisfactory, that the class of engines of

¹ Gentele, *Dingl. Pol. Journ.*, ccix, 369.

which it is a type, has been adopted as their standard heavy freight engine by the Baltimore and Ohio, Pennsylvania, Erie, Lehigh Valley and other leading railroads in the United States, and two "Consolidation" engines of the largest size, have recently been shipped by the Baldwin Locomotive Works, to Australia.

While there is obviously a wide range of difference, both as to design and detail, between the improved "Consolidation" engine of 1878, and the original "Camel" of 1848, the boldness and originality of conception, and the elements of practical value, presented at the early date of the latter, have given the "Camel" engines a prominent position in the history of American locomotive engineering, the record of which derives additional interest from the fact that their general principles, modified and improved by modern practice, are to be found embodied in the most successful type of freight engines now in use.

The first locomotives constructed in the United States with more than one pair of driving wheels, were the "grasshopper" engines of Phineas Davis, in 1834, one of which was exhibited at the Centennial Exposition. These engines had four coupled wheels of small diameter, driven from a counter shaft geared to a driving shaft rotated by two upright cylinders, and were succeeded by the "crab" engines of Gillingham & Winans, which were of the same general type, saving that they were of greater size and weight, and were provided with horizontal instead of vertical cylinders. The inadequacy of the "crabs" to fulfil the increasing demands of freight service upon heavy grades, developed the American eight-wheel connected engine, the first one of which, the "Buffalo," was built by Ross Winans, for the Baltimore and Ohio R. R., in November, 1844, and five others of the same pattern, known as "mud diggers," were made by him for the same road, between that date and December, 1846. It is not maintained that Mr. Winans was the *inventor* of the eight-wheel connected engine, but he was, without doubt, the first constructor of such an engine in the United States. M. W. Baldwin, of Philadelphia, built his first six-wheel connected engine in 1842, and it was not until 1846 that he commenced the construction of eight-wheel connected engines.

The six "mud digger" engines built by Winans, had the ordinary horizontal boiler, cylinders 17 x 24 inches, and eight driving wheels, 33 inches in diameter, coupled to a counter shaft placed immediately

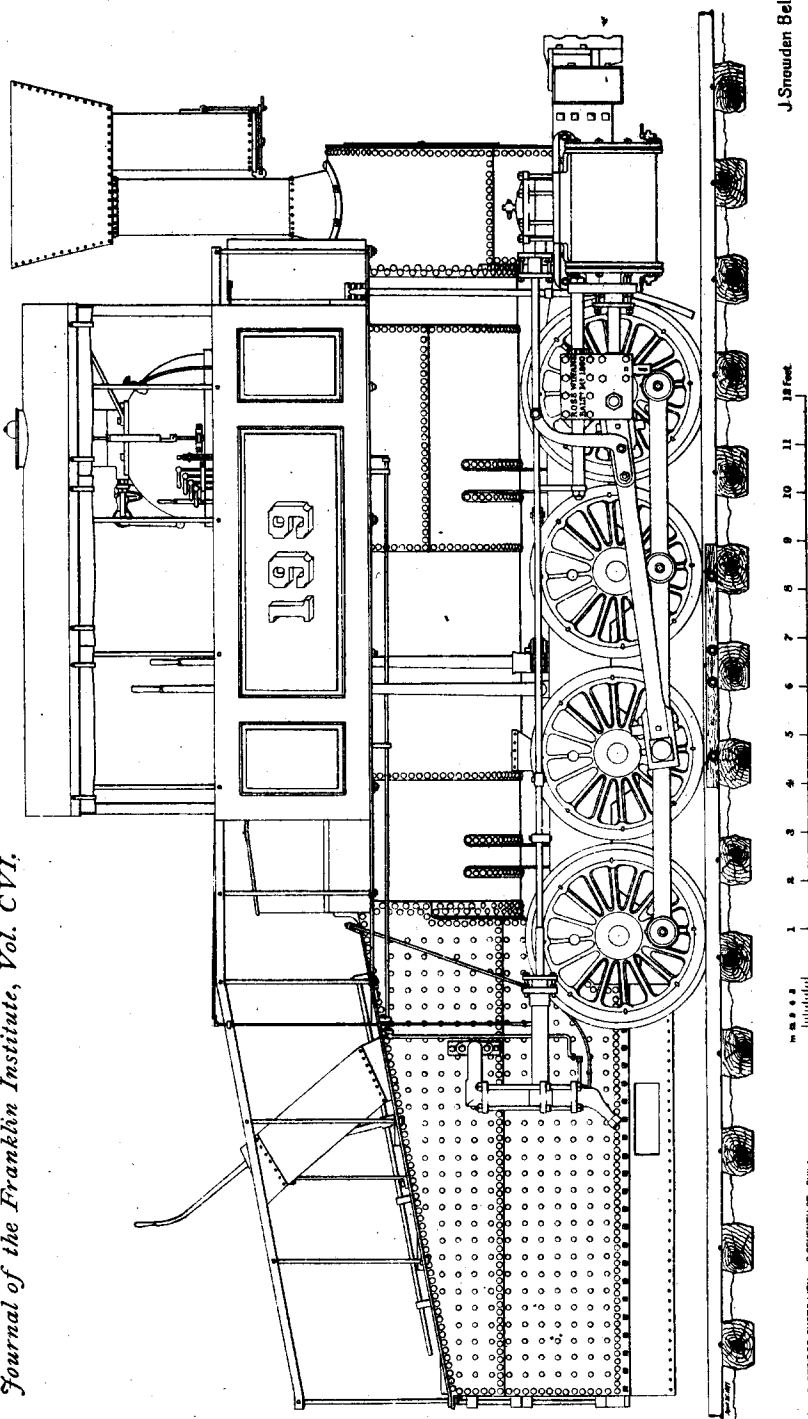
in rear of the fire-box and geared to the engine shaft, after the style of Gillingham & Winans' "crabs." Up to a few years past, several of them were yet in service as shifting engines, but they have all, by this time, been consigned to the scrap pile, although some of their cylinders are still doing duty in stationary engines.

The inherent defects of this type of engine, specially as compared with the Baldwin six and eight-wheel connected engines, necessitated the production of a more efficient and practical machine, and Winans' answer to this requirement was the "Camel" engine, the latest form of which is shown in the accompanying illustration. Beginning with the engine "Camel," in June, 1848, and ending with No. 219, in February, 1857, he built 119 of these engines for the Baltimore and Ohio Railroad, as well as a large number for other roads, among which were the Pennsylvania, Philadelphia and Reading, Northern Central, Cumberland and Pennsylvania, and New York and Erie. At the outbreak of the civil war, his shops in Baltimore were closed, and three of these engines in stock were subsequently purchased by the Baltimore and Ohio road, after which their manufacture was practically discontinued, a few only being made by parties by whom the shops were a short time operated.

Among the features of novelty which distinguished the "Camel" engines from prior constructions, may be enumerated the following:

1. The employment of eight driving wheels, set closely between horizontal cylinders and a long overhung fire-box, the width of which is equal to or greater than the distance over frames.
2. A fire-box having a downwardly and rearwardly inclined top.
3. A dome and engineer's house, placed on the top of the boiler, close to the forward end.
4. An upper chute for feeding coal through the top of the fire-box.
5. A fire-box having no water space on its rear side, which was closed by doors, so as to expose its entire area when required.
6. The abandonment of crown sheet stay bars, and the substitution of stay bolts, connecting the crown sheet with the outer shell.
7. The use of a half-stroke cam, as a means of effecting cut off.

All these engines were substantially of the same pattern, except as to the fire-box, of which there were three classes, the short, medium and long; the latter, which is shown in the illustration, having as great a length as 8 feet, 6 inches, and a width of 4 feet. The grate surface of the medium class was $6 \times 3\frac{1}{2}$ feet, giving the then enormous area of 21 square feet. The boiler, of $\frac{5}{16}$ iron, was



THE CAMEL ENGINE OF ROSS WINANS.

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46 inches in diameter. The cylinders (except in a few of the earlier engines, which were only 17 inches) were 19 inches in diameter, and 22 inches stroke, and the diameter of the driving wheels, in all cases, was 43 inches, with an extreme wheel base of only 11 feet, 3 inches. The front and rear wheels only were flanged, and end play was left in the boxes, to admit of the passage of the engines around curves. Chilled cast iron tires were used, fastened by hook headed bolts, passing between the centre and tire, and, in the earlier engines, chilled wheels without separate tires were employed. The weight of the engines varied from 25 to 29 tons (of 2000 lbs.). The valve motion was of the old "drop hook" pattern, and the valves could be operated either by an eccentric or a half stroke cam for cutting off, as desired.

In regular service, these engines hauled eight loaded freight cars, 20 tons (of 2000 lbs.) each, up grades of 116 feet to the mile, with frequent curves of 600 feet radius, but they have, for a period of two months, performed the remarkable and probably unparalleled duty of hauling a tender and one loaded car up a grade of 1 in 10, or 528 feet to the mile, having curves of 300 and 400 feet radius, at a speed of 13 miles per hour. This was done upon a temporary track laid over the Kingwood Tunnel, on the Baltimore and Ohio Railroad, and Benjamin H. Latrobe, Esq., the engineer in charge of the work, states the total gross weight to have been 120,000 lbs., the total resistance and traction required to overcome it, 13,828 lbs., and the adhesion required $\frac{1}{4.05}$ of the weight on drivers; further, expressing his belief that the limit of adhesion had been fully reached. Over another temporary track at the Board Tree Tunnel, having grades of 1 in 23 (229 feet to the mile), and curves of 300 feet radius, from sixty to seventy freight cars, and two passenger trains were daily taken by four "Camel" engines. Upon levels, and grades less than those before referred to, the loads hauled by these engines were equal to those of any other construction prior to the "Consolidation," and greater than most of them.

The inclined fire-box was patented by Ross Winans, May 9th, 1854, and was substantially adopted by James Milholland, Master of Machinery of the Philadelphia and Reading Railroad, in two passenger engines built by him in 1859, since which time, all, or nearly all, of the engines built by that company have contained it. In 1875, the Pennsylvania Railroad adopted the "Consolidation" as their

standard heavy freight and helping engine, and prepared a design, differing, in some particulars, from that of the original engine, among which was the substitution of the Winans' inclined fire-box for the wagon top fire-box used in the Baldwin Locomotive Works construction. The system of staying the crown sheet by stay bolts, connecting it with the outer shell instead of crown bars, is also adopted in the Pennsylvania "Consolidation," and is, moreover, in the "Bel-paire" furnace, coming into general use in continental Europe.

The imperfections of the "Camel," both in design and construction, were many, and the class is fast going out of existence, but it has done, and to-day is doing, good service. It first practically demonstrated the superiority of the eight-wheel connected engine for heavy traffic, and while for a time the ten-wheel engine met with greater favor, the revival of the eight driver type in the "Consolidation" class, evinces that thirty years' experience endorses that demonstration. It may be urged that the two-wheel truck of the "Consolidation" is an important factor, but in the view of the writer, this is questionable. In a ~~1,000,000~~ lb. engine it carries but 12,000 lbs., and engines of this class have run satisfactorily with it removed. In the consideration of the "Camel," relatively to the "Consolidation" type, it must be remembered that after due allowance for the lapse of time between them, and the perfection of detail and workmanship in the later engine due thereto, it is the comparison of a 60,000 lb. and a 100,000 lb. engine, and a 19 x 22 inch cylinder against a 20 x 24 inch. Each of them is a credit to its designer and his time, and the reviewer of thirty years hence will doubtless have before him a structure which will make the "Consolidation," like the "Camel," a thing of the past.

Heat of Molecular Rotation.—Hermann Herwig has examined the development of heat which arises in consequence of the rotation of molecular magnets, or of electrolytic molecules. The phenomenon was first observed by Joule, and has been attested by others, but no direct investigations have hitherto been instituted to determine its precise character. Herwig's experiments show that, after eliminating the influence of induction currents, there is a considerable quantity of residual heat, which is due to molecular rotation.—*Ann. d. Phys. u. Chem.* C.