
# R&LHS Newsletter

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**COVER: D&RG #1526, a M-67, has just uncoupled from the caboose (shown to the left on the original print), so it was probably providing helper service to the eastbound freight at Moffat Tunnel in 1947. Don Ball, Jr. photo, RGM&HS collection.**

## Printing Delay for *Railroad History* No. 190

A problem has arisen with the four-color press at our print shop. A portion of No. 190 (Spring-Summer 2004) was completed when the rolls malfunctioned, necessitating a major delay as new controls are ordered and installed. As of this writing (June 21), it appears that the issue won't be in the mail until the end of July.

I appreciate your understanding. A preview of No. 190 can be seen at: www.rrhistorical-2.com/rlhs/rrhistry/current.html

Mark Reutter, RRH Editor

# Comments on Newsletter

It looks just like RRH should look! And the subject matter — locomotives and railroad history. A radical approach if ever I saw one. Looks and reads just fine! — Vern Glover

I enjoyed Eugene Huddleston's article on A. G. Trumbull and AMC very much, most interesting, and with logically developed conclusions. — Don Leach

I received … the excellent *Newsletter* which I read nearly immediately cover to cover. — Alden Dryer

The new form of R&LHS *Newsletter* is great and am glad to see it. … I do think your latest version is a great improvement over the old. More class too. — Jim McFarlane

I like to new format for the *Newsletter*. I hope a majority of other readers do too. The articles selected for this issue were excellent too, although I am probably prejudiced in this respect since the one on "loops" was written by the late John Humiston, a Chicago Chapter member. — Charles Stats

Note: Use CHARCOAL lighter fluid to help remove the tabs and to wipe the glue off the paper. R&LHS

**PM #1225, at Bannister, Michigan, on May 31, 2003, shows that the AMC design still runs very well. Many new parts (piston rings, stay bolts, main driver springs, syphon, etc.) keep it running. Photo by Adrienne Scholl. Courtesy Michigan State Trust for Railroad Preservation (Project 1225).**

## Newsletter Notes

I had a Mac attack my *Newsletter* files of the previous issue. Raintree Graphics's PC went down, so they transferred the *Newsletter* to their Macintosh which doesn't have fractions. On page three, end of paragraph on notes is **7.25 inches**, page sixteen, Alaska is **1.5% grade**, and page seventeen, Morenci is for **1.5 miles**. Also delete the two extra lines at bottom of page seven. R&LHS

# Photo "Contest"

### Sort of

About 70 of us, plus a few regulars, performed a reenactment of the Golden Spike Ceremony, complete with a tolling of the bells amid silence in tribute to President Reagan on June 11th. I personally had a role of color guard. Adrian Ettlinger, who knows Morse Code, tapped out "DOEN" (he got distracted by his speaking role) at the proper moment. It was fun.

I now present the following challenge. I will devote the center eight pages of the next issue to photos taken by the attendees with the best shot matching the famous photo (see below for 1998 photo) as the 9x12 center fold. With some luck ($310.57 more is needed for color printing to be raised by advertising and/or donations) the full eight pages can be in color. Send donations to me.

For those on the trips (yes, please include all aspects of the convention) select your best shots and send them to me. If you took slides or color print film, send the slides or negative strips (you may include a print so I can see which one you want). All photos and negatives will be returned. If you took digital photos, send, via e-mail or on a CD or floppy, the file as it came from your camera. Try to avoid JPG conversion and use compressed TIF if possible. Add your captions for full effect. The prize? National recognition. R&LHS

**1998 R&LHS Convention. Courtesy of the Golden Spike National Historic Site.**

# Counterbalancing 10-Coupled Power

**by Don Leach**

Powering five driving axles in a single engine (called "ten-coupled" for the number of drive wheels) offered a special challenge to steam locomotive designers and shop men. Reciprocating and rotating parts from pistons to drive wheels could cause rough riding and damage to the track without proper balancing. Previous broad generalizations of this subject suggest an examination in detail would be helpful. Variables affecting balance and overall roughness of ride include reciprocating weight, driver diameter, construction materials, connecting rod design, expected operating speeds, etc. The analysis of fundamental mechanical principles develops comparative "figures of merit" for evaluation. That is my intent here.

## DESIGN

To understand the improvements made, one can first examine connecting rod design and practice during the period just before WW I and through the 1920s, the period when large 10-coupled power first appeared and then attained widespread use. A very common type of main rod design was the open back end, assembled with large bolted blocks, brasses and retainers. This is commonly illustrated in period photos of USRA power, and preceding and following power into the mid-1920s. Its advantage was quick convenient replacement of main rod crankpin brasses, the brasses subject to the greatest wear, without removing the main rod from the crosshead, considerably easing handling, and saving significant shop time. Similar designs were common in the 19$^{th}$ century. This made perfect sense during the "drag" era, with severely restricted speeds, an era which prevailed until the advent of Super Power encouraged higher speeds

Its principal disadvantage was the large mass applied at the worst possible location, from a counterbalancing perspective, right at the main crankpin, requiring great weight for counterbalancing rotating weight, thereby reducing available weight to counterbalance reciprocating weight and forces. This was most problematic on 10-coupled power. The large mass also imposed high dynamic loads on the crankpin at higher speeds.

During the late 1920s and into the 1930s, as operating speeds increased, these connecting rods were replaced with more modern closed-end designs, with varying provisions for brass replacement, by "shrink fit" or in some cases requiring brasses cast in place, or employing floating bushings, for the reasons just described. The improvement in connecting rod construction brought a significant improvement in counterbalancing, and reduction in track maintenance. This rod replacement was often done selectively according to engine assignments. For example, Pennsy installed modern main rods on its N-2sa USRA 2-10-2s, for general road service, but not on its N-1s class assigned entirely to mineral service to and from lake ports.

Another main rod design of interest, innovated by Lima with its Superpower initiative, was the tandem rod, sometimes called the articulated main rod by Lima. By employing a fixed bushing in the main rod, which had a forked end surrounding the rearward side rod, a portion of main rod forces were transmitted directly to the rearward drivers, thus reducing force on the main crankpin. This innovation was likely motivated by the increased main crankpin loads from Lima's high horsepower engines, and resulting wear and overheating of brasses. Conversely, this design also increased weight at the main rod back end, aggravating counterbalance problems. This feature offered advantages at low speeds and with heavy loads, such as in climbing the Berkshires on the B&A, but these advantages would be overcome by the weight and counterbalance problems as speed increases.

Some very clear illustrations of tandem rod use are provided in *Locomotive Quarterly* vol. VIII no. 2, with the article "Texas Types of the Burlington Route." These 2-10-4 engines were built by Baldwin in 1927 and 1929, designated class M-4 for coal service, and originally employed massive tandem rods, though constructed of chrome-vanadium steel (*Railway Age* 6/23/28), a major innovation. The illustrations clearly show the changes to connecting rods resulting from rebuilding to class M-4a, for improved speed in general service.

Reducing cylinder diameter to 28" from 31" on the CB&Q engines resulted in an 18.4% reduction in maximum connecting rod compressive load, and a corresponding reduction in cross-section. Further, installing conventional tapered main rods with floating bushings and cross-counterbalanced disc main drivers achieved further counterbalance and speed improvements. This required an altered side rod with knuckle pins intermediate to the 3rd and 4th drivers. The limited cutoff feature was also removed, to improve starting characteristics with the smaller cylinders.

It is interesting and logical that Bessemer and Lake Erie, which acquired 47 near duplicates of the

Burlington engines, made no changes to improve speed, since its Texas types served entirely in coal and iron ore service. These also had a higher 96,700 lbs tractive effort, since they did not have limited cutoff. A dozen of these later served DM&IR.

It seems often to be assumed that all 10-coupled power was similar, with similar limitations and problems. This is not the case, as the characteristics depend very much on individual specifications and, of course, actual operating conditions. The Union Pacific, for example, tended to emphasize speed in its tough competitive battle with the Santa Fe and other Western roads. It limited its driver axle loads to 59,500 lbs until the mid-1930s, long after others had raised limits sometimes to 70,000 lbs or more. It also specified the relatively modest cylinder dimensions at 29" X 30" for its 2-10-2s, producing a similarly modest 70,500 lbs starting tractive effort. These specifications allowed much lighter connecting rods and other reciprocating parts compared to say the Erie R-1s and R-2s with their 31" X 32" cylinders, and nominal 83,000 lbs TE. All of these engines had 63" drivers, which were standard for medium sized (non-articulated) freight power preceding the era of Super Power, where 69" to 70" became standard.

The results were predictable, actually. Union Pacific's engines often attained 50 mph, (some sources say 60 mph, *Locomotive Quarterly* vol. XI no. 3, "Union Pacific Engines in the Blue Mountains") and were regularly assigned to mountain passenger service, while the Erie engines were really suitable only for mineral or helper service, and became noted as rail kinkers when assigned to merchandise traffic, whenever they exceeded 30 mph (*Baldwin Magazine*, April-July 1934). This made the Erie Berkshires of the late 1920s (with 70" drivers) most welcome indeed! This comparison illustrates that seemingly small changes in specifications can produce major results.

An important improvement came with the 69"-70" drivers as first employed by C&O T-1s of 1930. This sizable increase in diameter on a 2-10-4 allowed room for the required counterweights in the larger drivers, and also reduced driver rpm, allowing 40-50 mph operation for extremely large 10-coupled power with high tractive effort and heavy connecting rods. In 1937, Santa Fe employed 74" drivers on its 5001 class and other innovations for improving power and speed!

## MATERIALS

The improvements made possible with high-alloy connecting rods are major, and often overlooked. In fact, it is no exaggeration to say that this was the most important single improvement in the counterbalancing of

10-coupled steam power. This improvement in material is dramatically illustrated in results reported for Chicago Great Western 2-10-4s by *Railway Age*, vol. 110 no. 14, 4/5/41. These Texas types were built in 1930 by Lima and Baldwin as essential duplicates of the Texas & Pacific engines of 1925, which originated the type. When refitted with chrome-vanadium steel connecting rods and rebalanced drivers, calculated dynamic augment at 60 mph (that is, pounding on the rails) was reduced from 34,200 lbs to 2700 lbs, a figure even lower than the original value of 3800 lbs at 20 mph (Table 3). Surprisingly, they retained the tandem rod construction originally provided. Some roads used chrome-nickel alloys instead. Southern Pacific refitted fleets of engines with alloy rods, extending even to light Harriman 2-8-2s, after discovering that the lessened dynamic load reduced brass wear enough to pay for the improvement. Allowed compressive stress was increased by 25% over heat-treated carbon steel, whereas tensile strength was increased considerably more.

All of the 10-coupled power noted for fast running employed alloy rods, including Santa Fe 5000s, Illinois Central rebuilt 2-10-2s, Canadian Pacific Selkirks and of course the rebuilt Burlington and Chicago Great Western engines. Selkirks were allowed 65 mph for regular passenger assignments, while IC 2-10-2s attained 60 mph on Iowa meat trains. Santa Fe 5000s attained 70-75 mph in occasional passenger, express and troop train service.

An anecdote about WW II, and its restrictions by the War Production Board on use of alloy steels is of interest. Some may recall that N&W was not permitted alloy steel connecting rods for its wartime class J-1 4-8-4s, nor metal for streamlining. They were built with heavy carbon steel rods and larger counterbalancing weights on drivers. Many other roads encountered similar restrictions. Santa Fe, however, was allowed alloy steel rods for its 25 wartime 5011 class 2-10-4s. The reasons are really quite logical, if one examines the details and circumstances. N&W could achieve satisfactory speeds and operations with its modern 8-coupled 4-8-4s, operating in "mountain" territory not requiring high passenger train speeds. The Santa Fe, however, would have been crippled in desert operating speeds with carbon steel rods on 10-coupled Texas types, over an artery vital to supplying the Pacific war, so they were provided the required alloys. After the war, N&W, acquiring alloy rods, rebuilt and redesignated its wartime engines as class J, and applied streamlining. The 5011 class was notably heavier than the 1937 5001 class because of material restrictions on components other than connecting rods, as were the 2900 class 4-8-4 compared to prewar engines, a situation typical throughout the country. In some cases, including for the 5011 class, the added weight improved adhesion and over the road performance.

In retrospect, it is somewhat puzzling that application of alloy rods was not more focused and selective. Since the major difficulty in weight control is for the main driver, one would expect flanged alloy main rods and center side rods, while slab carbon steel rods would seem perfectly satisfactory for the end main rods. Perhaps railroads wanted to avoid differing handling and machining characteristics, or a possible mix up on materials for replacement rods. Perhaps there was concern over differing thermal expansion for dissimilar material. Many roads did apply alloy main rods, while retaining carbon steel side rods, a partial realization of potential economies, while maximizing operating benefits.

## ANALYSIS

Mechanical fundamentals and associated mathematics affect an understanding of counterbalancing. The appendix provides these fundamentals, with an explanation in simplified form for comparison purposes only, not for design. With these fundamentals, tractive effort is the predominant parameter, for two models, not driver diameter as is often supposed. Rod mass increases as the square of driver diameter, due to increased span length of connecting rods, compensated for by reduced rpm, with effects inversely proportional to the square of driver diameter.

Table 1 presents numerical results of the inverse of Fc, required centripetal force, providing a useful figure of merit for comparison. Both models indicate results in reverse order of tractive effort, with but two exceptions, the C&O T-1 and Pennsy I-1sa. These exceptions will be discussed below. The second model represented by equation (15A) is more sensitive, with a high/low ratio of 1.81, compared to 1.44 for the first model per equation (15). This agreement inspires some confidence in the approach. Engines with alloy rods are ranked separately, since the two categories are not directly comparable.

Table 2 addresses a fundamental neglected by Table 1, that larger drivers provide more space for counterbalance weight. For present purposes, this space is considered proportional to area, hence D squared. In fact, a cubic relationship is possible, since location of counterbalance weight at larger diameters has more beneficial effect than weight closer to the center. The analysis of this is complex, and is a focus of future work. Realistically, a difference in rank of 1 should be considered insignificant, but 2 would be significant.

Column (i) presenting a ratio of the two models' results, shows some groupings of engines with exceptionally high and exceptionally low TE.

There are some notable anomalies between tabulated results, and known performance in operation. In particular, the Pennsy I-1sa 2-10-0 shows a last place ranking in Table 2, but was allowed 50 mph in service, though generally assigned to mineral trains, or as pushers on heavy grades. Pennsy's early adoption of 130 lb rail is likely a significant factor in the 50 mph speed allowance. The I-1sa design was actually quite sophisticated, with hollow-bored crankpins with grease reservoirs, heat-treated carbon steel flanged rods, and other features quite advanced for 1916. In fact, Pennsy data shows that the J-1 2-10-4s, nearly identical to the C&O T-1, had 37% more dynamic augment at 50 mph compared to the I-1sa (*Pennsy Q Class*, Classic Power 5, Exhibit 3), in spite of 70" drivers compared to 62" for the 2-10-0s. Hats off to Axel Vogt, for a great drag engine design, though they were known to be rough riding for the crew. This shows that great design can transcend ordinary limits.

The USRA heavy 2-10-2 of 1918-1919 shows quite a good ranking, yet the Pennsy, with a fleet of 130, allowed only 35 mph for this design, while Burlington, Colorado & Southern and Erie allowed 45 mph. The latter figure, however, was after the massive open-end main rods were replaced with modern designs. Later, after WW II, Burlington and C&S installed chrome-vanadium main rods, achieving improved counterbalance and reduced track maintenance. These speeds are comparable to very similar designs for Santa Fe, Southern Pacific and others.

Experience on the Seaboard with light 2-10-0s is also worthy of note, from a group of 23 Russian Decapods and 28 others of improved design, both shown in the Tables. Both were widely used on other roads, including the Gainesville Midland, where light rail or swampy conditions precluded heavier power or higher axle loads. Generally operated in slow service, they proved surprisingly agile when pressed, achieving 45-50 mph on occasion. (*Locomotive Quarterly* vol. XXII, no. 4, "The Seaboard Air Line's Decapods"). An explanation would be that exceptionally light reciprocating parts, allowed by small TE, compensated for small drivers of 52" and 56".

The lone 8-coupled engine in the tabulation, the D&RG M-67, ranks first in Table 2, but with only trivial differences compared to the Union Pacific TTT (UP talk for Two Ten Two) or Seaboard Decapod. This confirms that tractive effort is the dominant consideration, not the number of coupled drivers. It might actually be argued that the Union Pacific TTT could achieve better counterbalance because it has five pairs of 63" drivers in which to locate counterweights, rather than four. Another trick to improve counterbalance on engines with

2-wheel engine trucks, is a lengthened piston rod, and correspondingly shortened main rod and relocated crosshead, as exemplified by Santa Fe 5000s and L&N 2-8-4s.

There is an interesting discussion of engine balancing in the current ***Prospector***, vol. 2 no. 4, published by The Rio Grande Modeling and Historical Society, in "3-Cylinder Locomotives and the Denver and Rio Grande Western's M-75s" by Robert B. Schaefer. It cites the landmark industry source, *The Balancing of Engines*, (D.E. Dalby, 1929), a major treatise on dynamic balancing. This article confirms the counterbalancing misjudgments of Baldwin during that early Super Power era, and its lag in adopting disc drivers and cross counterbalancing. Alco took the lead in this respect. Those roads buying Baldwin power which avoided these problems — including Santa Fe, Southern Pacific, Northern Pacific, Burlington, etc. — enforced their own methods and calculations.

Hopefully, the clarification provided by this investigation and survey will invoke further thought and insights from others. Thanks for your patience.

### Notes for Table 1 and 2 (pages 12-13)

(a) 1000 times Reciprocal Fc from Eq. (15A) 1000 used for convenient magnitude

(b) 100 times Reciprocal Fc from Eq. (15) 100 used for convenient magnitude

(c) Original specifications at 190 psig. Erie, Burlington, others upped to 200 psig

(d) Heavy 63" drivered 4-8-2 included for comparison to UP TTT .

(e) Below this line, engines have Alloy Rods, usually chrome-vanadium

(f) Varies with boiler pressure, typical 240 psig selected

(g) $D^2$ factor recognizes space in driver for counterweights, ~ area and ~ $D^2$

(h) Similar to (g), except using model of Eq. (15A)

(i) Represents ratio of model Equation (15) results to model Equation (15A)

(j) Where Models agree, that rank was selected. Otherwise, ranking based on sum of two models. Selkirk tied with M-4a, ranked 2 from operating history. IC 2-10-2 and CGW 2-10-4 judged a tie from operating history.

(k) Carbon Steel and Alloy Rod Engines ranked separately, not directly comparable.

## TABLE 1 - Engine Specifications and Calculated Parameters

| Class | TE K lb | D in | $D^2$ | S in | (b) $\frac{100}{S^{2/3}\,TE^{1/3}}$ | (a) $\frac{1000}{TE^{2/3}\,[DS]^{1/3}}$ | Notes |
|---|---|---|---|---|---|---|---|
| C&O T-1 | 93 | 69 | 4761 | 34 | 2.10 | 3.67 | |
| Erie R-1 | 83 | 63 | 3969 | 32 | 2.27 | 4.16 | |
| USRA 2-10-2B | 74 | 63 | 3969 | 32 | 2.36 | 4.49 | (c) |
| UP TTT | 70.5 | 63 | 3969 | 30 | 2.50 | 4.74 | |
| Seaboard GM 2-10-0 | 46.5 | 56 | 3136 | 28 | 3.02 | 6.66 | |
| Russian Dec. | 52 | 52 | 2704 | 28 | 2.91 | 6.33 | |
| Pennsy I-1sa | 97 | 62 | 3844 | 32 | 2.16 | 3.77 | |
| D&RG M-67 | 67 | 63 | 3969 | 30 | 2.55 | 4.90 | (d) |
| SF 5011 | 93 | 74 | 5476 | 34 | 2.10 | 3.58 | (e) |
| IC 2-10-2 | 91 | 64.5 | 4160 | 32 | 2.20 | 3.88 | (f) |
| Burl. M-4a | 83 | 64 | 4096 | 32 | 2.27 | 4.14 | |
| CP Selkirk | 77 | 63 | 3969 | 32 | 2.33 | 4.37 | |
| CGW 2-10-4 | 83 | 63 | 3969 | 32 | 2.27 | 4.16 | |

# TABLE 2 - Calculated Parameters and Engine Rankings

| Class | (g) $\frac{D^2}{S^{2/3}\ TE^{1/3}}$ | (k) Rank | (h) $\frac{D^2}{TE^{2/3}\ [DS]^{1/3}}$ | (k) Rank | (i) $[TE\ D/S]^{1/3}$ | (j) Overall Rank |
|---|---|---|---|---|---|---|
| C&O T-1 | 100 | 2 | 17.4 | 5 | 5.74 | 4 |
| Erie R-1 | 90.1 | 6 | 16.5 | 7 | 5.47 | 6 |
| USRA 2-10-2B | 93.7 | 5 | 17.8 | 4 | 5.26 | 5 |
| UP TTT | 99.2 | 3 | 18.8 | 3 | 5.29 | 3 |
| Seaboard Dec. | 94.7 | 4 | 20.9 | 1 | 4.53 | 2 |
| Russian Dec. | 78.6 | 8 | 17.1 | 6 | 4.58 | 7 |
| Pennsy I-1sa | 83.0 | 7 | 14.5 | 8 | 5.73 | 8 |
| D&RG M-67 | 101 | 1 | 19.5 | 2 | 5.20 | 1 |
| SF 5011 | 115 | 1 | 19.6 | 1 | 5.87 | 1 |
| IC 2-10-2 | 91.5 | 4 | 16.1 | 5 | 5.68 | 4 |
| Burl. M-4a | 93 | 2 | 17.0 | 3 | 5.50 | 3. |
| CP Selkirk | 92.5 | 3 | 17.4 | 2 | 5.33 | 2 |
| CGW 2-10-4 | 90.3 | 5 | 16.5 | 4 | 5.47 | 4 |

# APPENDIX A
## Variables Affecting Counterbalancing

An exploration of their interaction, and a simplified analysis for comparison purposes.

The intent is to arrive at a "figure of merit" facilitating comparison. The governing load condition for steam locomotive connecting rods is the compression load, where the rod in effect behaves as a long slender column, with crankpins allowing vertical rotation at each end. From Timoshenko and Young, "Elements of Strength of Materials,"

$Pcr = Pi^2 E\ I / L^2$ (1) solving for I $I = Pcr\ L^2 / Pi^2 E$ (2)

By working in ratios and proportions, for comparison only, we can dispense with all constants, Pi and E (modulus of elasticity, constant for a fixed material). L is the length of the column; for our purpose L is the same as driver diameter D (3) where the small driver spacing is comparable to the reinforced journal ends of the rod. I is moment of inertia, an indication of resistance to bending. Pcr is critical compressive force, at which rod bending begins and commences structural instability. Pcr is proportional as follows:

$Pcr \sim TE\ D / S$ (4) combining with (2) $I \sim TE\ D^3 / S$ (5)

Where TE is tractive effort and S is stroke. From Timoshenko, for a rectangular rod section of width b (taken constant) and height h $I = bh^3 / 12$ (6)

Ignoring constants, combining with (5) $I \sim h^3$ (7) $h^3 \sim TE\ D^3 / S$ (8) $h \sim D\ [TE/S]^{1/3}$ (9)

For rod mass, m = Ro bh L = Ro bh D (10) from (9) and dropping constants $m \sim D^2\ [TE/S]^{1/3}$ (11)

Note the important result that rod mass m increases with the square of diameter D. This is, however, compensated for by the effect that rate of rotation Omega varies inversely with D, and centrifugal force Fc varies directly with the square of Omega!

$Fc = m\ OM^2\ r$ (12) radius of rotation r ~ stroke S , and OM ~ 1/D

$Fc \sim m\ S / D^2$ (13) substituting from (11) above, we obtain

$Fc \sim \{D^2\ [TE/S]^{1/3}\}\ S / D^2$ then $Fc \sim S\ [TE/S]^{1/3}$ (14)

Thus we have the curious result, after all the computational sausage making, that connecting rod centrifugal force (or more correctly, the centripetal force required to prevent the rod from flying into space) depends only on stroke S and tractive effort TE !!

The Reciprocal of Fc is useful as an indicator of Locomotive Speed Potential (high score wins).

$1 / Fc \sim 1 / [S^{2/3}] [TE^{1/3}]$ (15)

There is also a possibly more sophisticated treatment considering required crankpin diameter dc , and bearing contact area ac , and using proportions (4) and (6). The crankpin is loaded in shear and bending by Pcr requiring the following:

$dc \sim [Pcr^{1/2}] \sim [ TE\ D / S ]^{1/2}$ $ac \sim dc \sim [Pcr^{1/2}]$ but req'd $ac \sim Pcr$

Therefore, bearing width / rod width $b \sim [Pcr^{1/2}] \sim [ TE\ D / S ]^{1/2}$ (6A)

From (5) $I \sim TE\ D^3 / S$ From (6) and (6A) $I \sim h^3 [TE\ D / S ]^{1/2}$ (6B)

and dropping constants $TE\ D^3 / S \sim h^3 [ TE\ D / S ]^{1/2}$ (6C)

then solving for $h^3$ and h $h^3 \sim [ TE\ D^3 / S ] [S / TE\ D ]^{1/2}$ $h^3 \sim [ TE / S ]^{1/2} D^{5/2}$ (8A)

$m = Ro\ bh\ D$ (10) $h \sim [ TE / S ]^{1/6} D^{5/6}$ (9A)

This model gives a great increase in TE effect compared to original (11).

$Fc \sim m\ S / D^2$ (13) $Fc \sim [ TE / S ]^{2/3} D^{7/3} S\ D^{-6/3}$

$Fc \sim TE^{2/3} [ D\ S ]^{1/3}$ (14A)

Note that by dropping dimensional constants, dimensional consistency is lost.

Now we can observe changes compared to previous b=constant model:

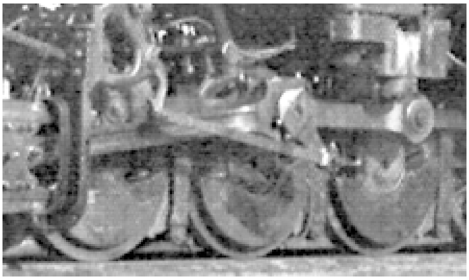
Previously $Fc \sim S^{2/3}$ now $\sim S^{1/3}$ Parameter effect is now reversed!

Previously $Fc \sim TE^{1/3}$ now $\sim TE^{2/3}$ Plus D is now a factor.

Again, the Reciprocal of Fc is used as indicator of speed potential, or figure of merit.

$1 / Fc \sim 1 / TE^{2/3} [ D\ S ]^{1/3}$ (15A)

Now parameters of interest will be calculated for the two models, then compared and analyzed. Results are shown in Tables 1 and 2, and discussed in the text.



**ABOVE: Note the change from as built M-4 (massive tandem rods shown above) to M-4a as rebuilt (much lighter conventional rods with knuckle pins, and tapered main rod with floating bushings shown below). Photo from *Locomotive Quarterly* Winter 1984, Vol. VIII. No. 2. by Robert J. Foster. BELOW: Photo by Charles T. Felstead.**

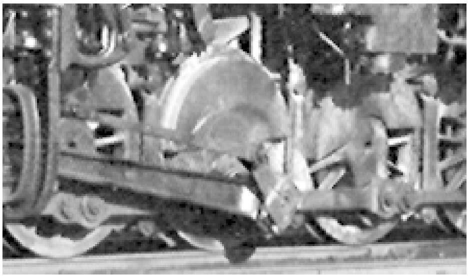


**Table 3***

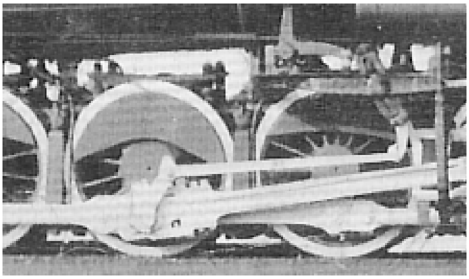
Comparative Calculated Dynamic Augment in Pounds at Speeds Chicago Great Western 2-10-4

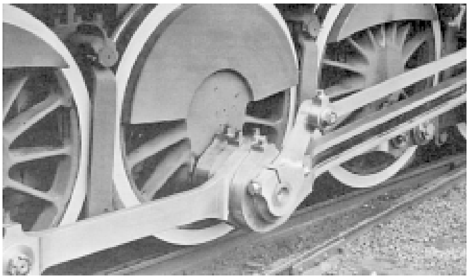
| Speed m.p.h. | Old Rods and Wheels | New Rods and Wheels |
|---|---|---|
| 5 | 238 | 19 |
| 10 | 950 | 75 |
| 15 | 2,140 | 169 |
| 20 | 3,800 | 300 |
| 25 | 5,935 | 469 |
| 30 | 8,550 | 675 |
| 35 | 11,630 | 918 |
| 40 | 15,200 | 1,200 |
| 45 | 19,230 | 1,520 |
| 50 | 23,770 | 1,875 |
| 55 | 28,800 | 2,265 |
| 60 | 34,200 | 2,700 |

* From Railway Age, April 5, 1941, *C.G.W. Freight Power Improved*

*Don Leach is a retired mechanical/process engineer who worked 11 years for Gulf Oil, 4 years for Bechtel, 4 years for MW Kellogg, and others. Mostly process plant design, equipment selection, contractor/vendor liaison, general calculations and specifications, rotating equipment, heat exchange, reactors, fractionation columns, etc.* R&LHS

**BELOW LEFT: USRA 2-10-2B with massive open-end main rod, as originally built, from Kalmbach's *Trains Album of Photographs*, no. 17, "Locomotives of the Pennsylvania Railroad." BELOW RIGHT: Lima A-1 tandem rod photo from *Super Power Steam Locomotives* by Richard J. Cook. Despite the ponderous size of the main pin connections, the forked main rod did transfer thrust to fourth driver.**





# B&M Perspective, The Station & The Dawg Wagon

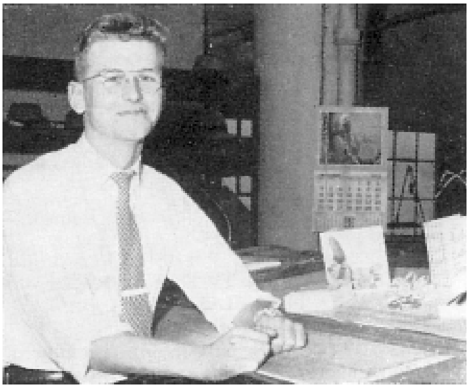
**By Alden H. Dreyer**

It has been nearly 40 years since the Boston and Maine Railroad disappeared (4/30/64) and over 20 years since Guilford Transportation Industries, Inc. purchased the Boston and Maine Corporation, Inc. (6/30/83). Things have changed since we had a Railroad-with-no-ampersand-please, but lets think a bit of what has not.

You can still board the cars in Washington and Philadelphia and New York City for Brattleboro, Bellows Falls and W R Jct and beyond. And likewise boarding in North Station will get you to Exeter, Dover and Wells. Folks in fancy dress still ride each morning from Fitchburg, Lowell and Rockport and the freights still whistle along the Stony Brook and through the valleys of the Millers, Deerfield and Hoosick Rivers.

Men who worked under Alan Dustin still switch the cars at East Deerfield and answer the telephones and change out the rails and chase the trespassers. Not to say there hasn't been natural attrition and new hires, but at least in Western Massachusetts, it's pretty much the same old crew. But all that will change in the next five years or so.

Perhaps the most constant item is a gentleman by the name of S. B. Culliford, who is listed in GRS ETT No.3 as Vice-President Transportation. When Whit Haynes retired as General Manager circa 1968, SBC took over that position and 35 years later, in his 70s now, he still holds that function. A rather amazing record considering the turmoil of the past half century.

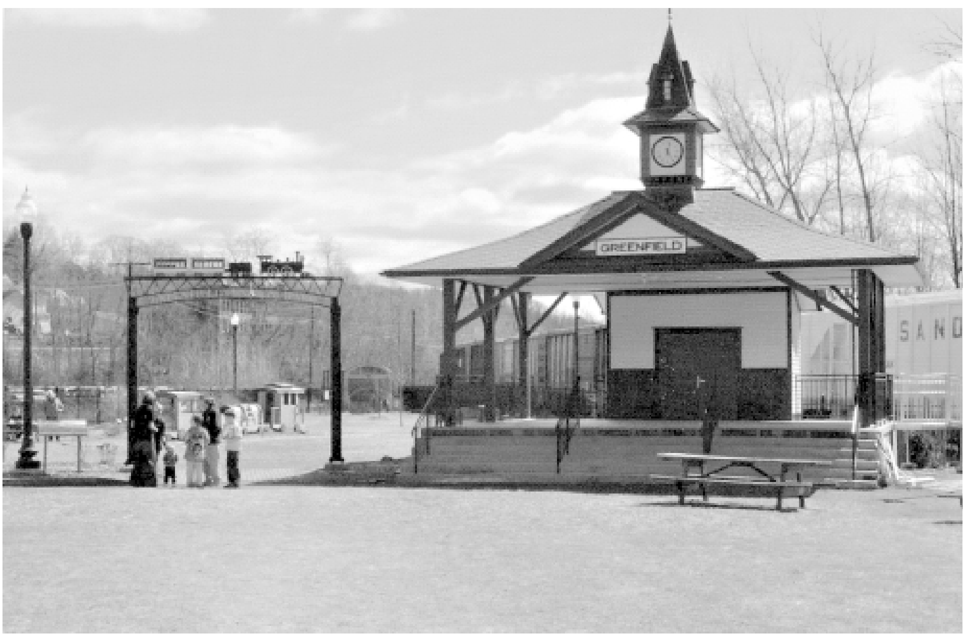


**Sidney B. Culliford as a signal draftsman in January, 1953, just prior to entering military service. Photo from *Boston & Maine Railroad Magazine*, March, 1953.**

Turning now to what has changed that you probably know nothing about: D. A. Biskerski retired recently as a GRS Train Operation Manager and was well known to everyone in operations and anyone who used a scanner. I trained David to become a DS in the early 1970s in Greenfield and was always proud of this particular student. What is noteworthy from a historical standpoint is that DAB was the last TOM to have worked in a former B&M office as a DS that was not in North Billerica. There is a lot to be said for the training you receive by personal contact with the employees that dispatchers were subjected to in Dover, Concord, Boston, Gardner and Greenfield but was, and is, noticeably lacking in North Billerica.

The Station, at the foot of Miles Street in Greenfield, Massachusetts, is simply the world's finest train viewing pavilion. It is accessible for the mobility handicapped, well lit and fenced and in the middle of a lovely park with normally adequate parking on premises. The site is that of the former T&G, FRR then B&M RR Station and is really in downtown Greenfield. There is a caboose museum to explore, lots to read and study and a wooden train for children of all ages to play on. Adjacent is the former B&M Fitchburg Division administration building that was opened on 01 March 1914 and locked for the very first time ever by this writer at 1930 hours on Thursday, 13 April 1972, after personnel and equipment had been disbursed. The building has not changed much since then and visitors are welcome to walk through during normal weekday business hours.

The Station was built with private funds and volunteer labor and, of course, serves many functions besides train viewing. The only negative here is the lack of trains during daylight hours when the park is open. The park is located in the wedge between the former Connecticut River Division



and Fitchburg Division main lines. The Conn. River is all but dormant with no more than a train a day.

The Fitchburg Division route will see 7-10 movements on a normal day. But since the railroad from Greenfield to Rotterdam Jct. is a single track mountain railroad, trackwork takes priority during daylight hours especially on weekdays during the warmer months. So you may see 5 trains at The Station, or none on any particular day.

Now if you visit The Station on a weekday, try to arrive hungry around the midday hours and look up Jim Breton at his Dawg Wagon on Main Street near the intersection with Routes 5&10. Jim is a personable young man who worked many years as a B&M trainman, then engineman, and then as a ConRail and CSX engineman. Why would a talented young man give up running thruough the beautiful Berkshire Hills, with an exciting, lucrative and secure career, and take up operating a hotdog cart in the dying industrial city of Greenfield? Catch Jim when he's not too busy and he may give you a hint. Tell him Alden Dreyer sent you. And talk to Jim before you give up that day desk job for the glory of running thruough those Hills on CSX or GRS. R&LHS

# TRADING POST

*Submissions should be made to the Newsletter editor via e-mail or mail for inclusion in the next issue. All items subject to editorial decisions as to content. Also posted on our Website. <http://www.RLHS.ORG>*

FOR SALE - PC Fonts for stationery to prototype lettering. $10.00 each, add $3.00 s/h.

ATLANTIC
COAST LINE
C&O FREIGHT AND LOCO
Chessie
Chessie System
CLINCHFIELD
ILLINOIS CENTRAL
MONON LINE
NICKEL PLATE ROAD
PERE MARQUETTE
SEABOARD

**Clifford Vander Yacht**, 2363 Lourdes Dr. W., Jacksonville FL 32210-3410.

WANTED - Steam, Diesel, and Electric Builder's and Number Plates. I have been collecting for 41 years, and I am still looking to fill voids and purchase traders. I am looking for a Rutland number plate with name cast in, PRR E-6 and T-1 original keystones, any early Pre-Alco number plates, early first generation diesel plates, a round Lima Shay plate, and many others. **Ron Muldowney**, 52 Dunkard Church Road, Stockton NJ 08559-1405, (609) 397-0293. <steamfan@crusoe.net>

FOR SALE - Dealer selling remaining inventory of Milepost 1: books, videos, pamphlets. Send LSSAE ($.60 postage) for list. All items subject to prior sale. Sale ends 12/31/2004. Derail Books, P.O. Box 10087, Eugene OR 97440-2087. No phone calls please.

FOR SALE - Dealer selling personal collection of RR magazines and Poor's Manuals. Many issues of R&LHS *Bulletins*, *Railroad Historys*. Send LSSAE ($.60 postage) for list. Buyer pays shipping. **David L. Dorrance**, P.O. Box 10087, Eugene OR 97440-2087.

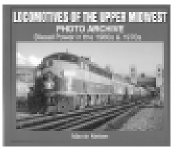
STILL AVAILABLE - The Chicago Chapter's reprint of *Rock Island's General Roster No. 66, of Sept. 1, 1925*, containing everything you would want to know about the company, its officers, agents, stations, structures, mileage, connections, clearances, and equipment, etc. at the time of its greatest prosperity. Everything except actual train schedules. 297 pages. Softcover. $20 plus $2 shipping. Order from: **D. T. Davis** Treasurer, Chicago Chapter, 2945 Everett St., Blue Island IL 60406.

FOR SALE - Railroad books (Fiction & Nonfiction), Videos, *Western Railroader* (loose and Bound), other magazines. For list, send your name and address to **David Graeber**, 7840 Antelope Rd. Apt. 112, Citrus Heights CA 95610. <ddgraeber@cs.com>

WANTED - Photos of the **St. Louis and O'Fallon Railway**, freight equipment, passenger cars, caboose, hoppers,. **Larry Thomas**, PO Box 1688, St. Louis MO 63188. (314) 535-3101. R&LHS

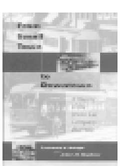
# New RR Books

*Press releases for new railroad oriented books appear here. They are not paid advertisements and carry no endorsement by the R&LHS. All items subject to available space and editorial decisions as to content. Photographs are limited to 7/8 inches high.*




**Locomotives of the Upper Midwest Photo Archive:** *Diesel Power in the 1960s & 1970s* by Marvin Nielsen with a personal look at makes and models of diesels used by the Soo Line, Chicago & North Western, Burlington Northern, Milwaukee Road, Wisconsin Central, Green Bay & Western and others. Softbound, 128 pgs., 10¼x8½, 122 B&W photos. $29.95 +$4.95 s/h. Iconografix Dept. PR, PO Box 446, Hudson WI 54106. (800) 289-3504.


**Classic Streamliners Photo Archive:** *The Trains and the Designers* by John Kelly features streamliners designed by Raymond Loewy for the Pennsylvania Railroad, Henry Dreyfuss for the New York Central, Otto Kuhler for the Milwaukee Road and B&O, and the Electro Motive Division styling team. Softbound, 128 pgs., 10¼x8½, 122 B&W photos & ills. $29.95 +$4.95 s/h. Iconografix Dept. PR, PO Box 446, Hudson WI 54106. (800) 289-3504.



Lawrence A. Brough and James H. Graebner brings you **From Small Town to Donwtown**: *A History of the Jewett Car Company, 1893-1919*. Started in Jewett, Ohio, and moved to Akron, the firm was never large, but gained an excellent reputation for its elegant, well-built wooden interurban cars. An extensive appendix is given on the Jewett production. Hardbound, 270 pages, 7x10, 101 photos, bibl., 2 indexes. $49.95. Indiana University Press, 601 N Morton Street, Bloomington IN 47404-3797. (812) 855-8817.

150 years ago, the Rock Island reached the Mississippi River and celebrated. **Grand Excursion on the Upper Mississippi River:** *Places, Landscapes, and Regional Identity After 1854* is edited by Curtis C. Roseman and Elizabeth M. Roseman. Whole sections explore the building of the railroad; give eastern newspaper accounts of the excursion; plus details of steamboating, the pictorial landscape, passenger trains along the scenic river, features of the river towns, river navigation, development of preserves and parks, the lumber industry and commercial fishing. Softbound, 272 pages, 6x9¼, $19.95. University of Iowa Press, 100 Kuhl House, Iowa City IA 52242.

ILLINOIS CENTRAL


**Rods Down and Dropped Fires:** *Illinois Central and the Steam Age — In Perspective* by Richard P. Bessette, is a new volume on the Illinois Central. With over 1,000 b&w photographs, this work presents an extensive view of the Railroad's steam locomotive photography archive in one definitive source. Hardcover, 608 pages, 8½ x 11, $59.95, $6 s/h ($5.10 tax for IL res.). RTN Press LLC, PO Box 2333, Orland Park, IL, 60462. R&LHS

# Mystery Photos

Here are some nice photos of engines and maybe an excursion. Can you identify any of these? With the photos run so far we have had fair results. The two aerial views of a yard published in the last *Newsletter* received no additional information. These here have been presented to the R&LHS Internet Forum (or RLHSGroup) without being identified. The rest of those 20 photos have a range of information from very basic to rather complete captions, thanks mainly to Thomas T. Taber, III, Herb Harwood and John Gruber.

**MY019** Taunton?

**MY021** M&STL #130


**MY006** Hayes collection, #51, Boxcar: MVRR 3841

Send information to Clifford J. Vander Yacht, R&LHS Newsletter Editor, 2363 Lourdes Drive West, Jacksonville FL 32210-3410 or via e-mail to CliffVDY@Juno.com.

**MY002** #331

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