Early Super Power — The B&A A1

by Brian Scace

The A1 Berkshire type on the Boston and Albany was a paradox. On the one hand it proved the theory, along with the Texas and Pacific 2-10-4, of "Super Power" on America's railroads. On the other, the New York Central did not embrace it as its next logical step in system-wide freight power development.

THE PROBLEM

The period immediately after World War I (1914-1918) saw American railroads returning to the private sector after United States Railroad Administration control ceased in 1920. The Boston and Albany's freight power, which had never been satisfactory before the war, still could not cope in a timely fashion with the road's two major geographical obstacles. Of these, the Charlton Summit at MP 57.53 with a 1.06% ruling grade WB paled before the crossing of the Berkshire Hills at Washington (MP 137.65) with a 1.65% ruling grade WB.

Although the main stem was only approximately 200 miles long, it was not unusual for freight traffic to crowd the then current 16 hour crew rules in traversing either of the two divisions (Boston-Springfield MP 98.33 and Springfield-Albany). There were two reasons for this. First, the available locomotives were inherently slow and, second, they lacked the power for other than short trains due to the resistance offered by the multiple sharp curvatures and gradients. This required that more trains be dispatched with more crews to move the same amount of tonnage as could be moved by fewer, more powerful locomotives.

The latter problem, power, was the first to be addressed by the post-USRA B&A, and reflected the predominant thinking of the day nationwide with respect to motive power design. **Tractive effort** was the number that almost solely preoccupied the engineering profession with regards to locomotive design at the time. Thus, the BA entered the 1920's with some large ponderous power that addressed the issue of tractive effort. Supplementing the old 4-8-0 (Mastodon) types from 1899 were the large G-type (Consolidation) with 63" drivers, 2-6-6-2 NE-type Mallets with 57" drivers, and H5 (Mikado) types with 63" drivers. By the end of USRA control, the Z-type 2-10-2 had been added to the roster as the next attempt at solving the problem.

The introduction of the Z allowed for the merciful withdrawal of the hopelessly obsolete Mastodons, and, along with the NE-type Mallets, represented the zenith of the tractive effort/brute force approach on the B&A. Although both types were extremely powerful for their day, they were dismally slow. They could pull longer trains than their predecessors; however this only proved a temporary improvement. The resulting reduction in train frequency soon was reversed by the brisk increase in business in the pre-Depression 1920's which ultimately required train frequencies to return to their previous saturated levels.

To continue this game, one would have to design a locomotive with still higher tractive effort. Because tractive effort is a function of weight-on-drivers, this would require either a larger locomotive with more drivers and the same axle loading, or a heavier one with the same wheel arrangement for a higher driver axle loading.

While the B&A was dealing with its traffic problems, the Central was fighting the same battle. In the East, the Central was working with American to develop the L1 (4-8-2) from the K11 (4-6-2) to increase tonnage while maintaining train frequency (remember the increase in number of similarly loaded driving axles as a method to increase tractive effort?). Meanwhile, on Line West, the H type (2-8-2 Mikado) had been developed to its maximum allowable axle loading (Our second case, where an increase in driving axle loading with the same number of drivers yields a tractive effort increase) with the H7 type.

The B&A, as well as the NYC itself, was severely restricted in its physical clearances. This disallowed further increase in the size of its locomotives. Axle loadings had reached their practical limits as well, making the second solution unfeasible. To make matters worse, a limit in train length was also at hand due to several factors such as application problems with the K Brake and the rather violent forces (train dynamics) on long trains negotiating multiple changes in curvature and gradient within their length. Other than double-heading power, the tractive effort battle was lost until the advent of the Diesel-electric, the AB Brake, and the more sophisticated draft gear of the post WW-II era.

The other avenue open for improvement was an increase in train **speed.** This requires an increase in **horsepower** for a given load while tractive effort (thus weight on drivers) remains constant. It was to this end that the engineering community turned its attention. The enthusiasm was supplied by Lima Locomotive (and to a lesser extent American Locomotive) with the weight of NYC's testing and engineering program thrown in behind it. The B&A was to reap great reward from it.

THE PLAYERS

Lima Locomotive (Lima, Ohio) was most famous before WW I as a producer of geared locomotives and small rod engines for industrial, short, and logging lines. In the years just prior to the USRA, they entered the road locomotive market (with an order for 4-6-2s for the Erie) in competition with the old standards Baldwin (Philadelphia, Pa.) and American (primarily Schenectady, N.Y.). The USRA aided in Lima's establishment in this new market with orders for standard 0-8-0 and 2-8-2 types during the war years. Being the newcomer, they established a reputation as being bright, innovative, and aggressive.

The NYC always had a habit of stimulating this sort of competitive thinking in the engineering fields for its own benefit. We can only surmise that the Central's lack of interest in Baldwin was due in no small way to that builder's stubborn refusal to abandon the tractive effort school of thought. Baldwin's close ties with PRR did no more to endear them to the Central than their conservatism. The argument that Baldwin was off-line has been used as well; however the validity of that argument is suspect as they were "off-line" to most of their best customers, such as Santa Fe. For whatever

Class A1a #1406 labors westward at Riverside on July 8, 1928. NYCSHS Purinton collection.

Next comes class A1a #1411 with an eastbound. NYCSHS Purinton collection.

reason, Lima and American were the builders that NYC favored and were the two players in the next chapter in steam locomotive development for that road.

In the period 1915-1921, over 30% of Lima's plant output was charged to the account of the New York Central Lines. Lima's interest in this account was certainly understandable, and their engineering "brain trust" consisting of William Woodard, Herb Snyder, and George Basford was eager to work with their largest customer and help solve the Central's traffic problems. Lima was ready to leave the quest for power/tractive effort behind in favor of the quest for speed.

The first result of this collaboration was a 2-8-2 built as a stock engine based on the existing H7. The arrangement was a simple one. Woodard et al. would propose to the Central studied recommendations for the improvement of the H7 limited only by the requirement not to exceed existing clearance dimensions or axle loading. Central and Lima would then design the locomotive based on Lima's recommendations. Lima would then build the engine at its own expense "for stock" and the Central would buy it only if they liked it. Lima would only benefit if their recommendations were proved correct and the prototype was successful. Because of the potential reward and a rather nasty sales slump at the time (only 9 locomotives ordered between January and November 1921), Lima accepted.

The result was H10, order number 1027, optimistically lettered as Michigan Central #8000. It was successfully demonstrated and purchased. Those interested in a more in-depth article on the H10 should see the 2nd Quarter 1985 *Central Headlight* for R.S.Curl's work.

The H10 was not an attempt at "Super Power"only because of the limitations placed on the original concept. Because of the requirement that the H7 weights and dimensions not be exceeded by the new design, the increase in horsepower resulted in a somewhat lower than desirable factor of adhesion (**adhesion** is derived from a power-to-weight ratio). It was, however, an outstanding proving ground for the appliances that would make higher horsepower locomotives feasible. Much was learned about the service behavior of those appliances, leading to their improvement.

At the same time that the NYC was working with Lima and the H10, the Central was also working on an improved L1 with American. Shortly after the #8000 was demonstrated, the first modern U.S. three-cylinder, rebuilt L1 #2568, appeared. Three cylinders was American's initial approach to the horsepower problem and the concept went on to zenith with the 9000 series of the Union Pacific. Maintaining the somewhat inaccessible workings of the center cylinder was rather labor and time intensive so, when the "Super Power" concept was proven to adequately address the requirements of American railroads using paired cylinders, the troublesome third cylinder quietly passed into history:

It should be noted that the engineering department of the Central was deeply involved in both projects so as to reap the benefits of both builder's expertise, and to select the most promising features of both designs. This philosophy was thought to inspire innovative competition between the builders, and was the hallmark of the Kiefer engineering dynasty well into the diesel era. It is hard to resist a philosophical comparison with the PRRs almost singular involvement with Baldwin during the same period.

The resulting analysis of the two designs was clearly in Lima's favor. Only one more L1 received a third cylinder while the H10 became the prototype for 301 examples. Unfortunately for Lima, however, the design was not proprietary to them because of the nature of NYC's participation, and American received orders for 186 of that number.

This did not signify any reduction in the Central's desire to continue locomotive development with American, however. Although NYC did not favor the three cylinder concept, many appliance advances on the H10 were duplicated on the 2568 and much was learned. American continued to work with NYC on the 4-8-2 wheel arrangement resulting in the excellent L2 fast freight design.

THE SOLUTION

While American was working with the Central on what was to become the L2, Lima took what it had learned and started on what Woodard et al. had already started to commit to paper. Much had been learned from the H10 and Lima felt it now had the experience to build on that knowledge and design and build a new generation of locomotive not constrained by an existing concept.

It was also decided that the design would be Lima's property, not NYC's, built by Lima and demonstrated nationwide. Lima's lawyers had apparently learned as much as the engineers. Although the Central continued to have significant input in the project, Lima now intended to have a revolutionary product ready to be marketed nationwide that was truly Lima's.

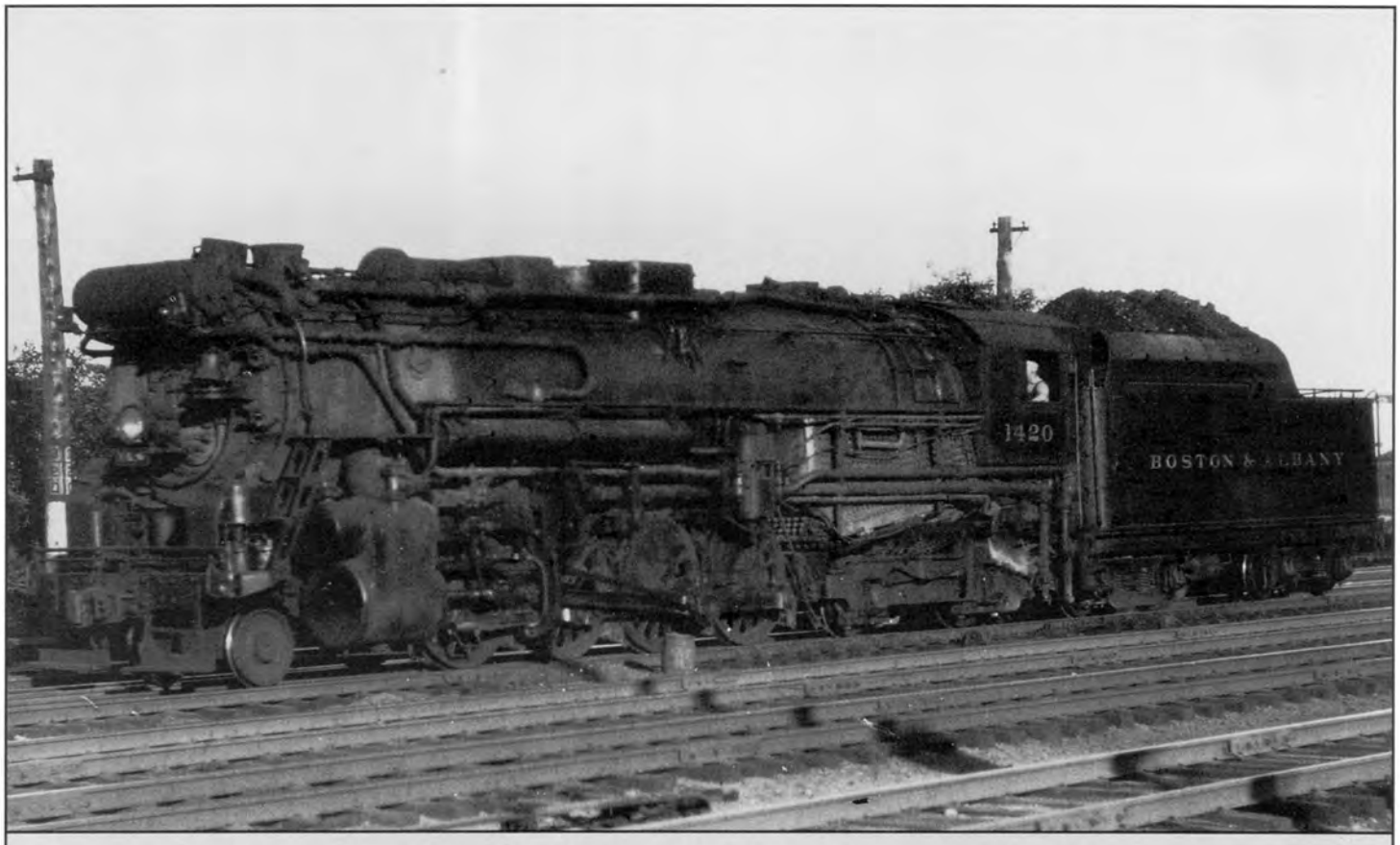
The idea of a standardized locomotive design was not new. Contrary to popular myth, steam locomotives were not all "custom" machines. There are many examples of standard designs built for many roads to include the early Stephensons, the U.S. Military R.R. 4-4-0s of the 1860s which became the "American Standards", the turn-of-the-century Alco 2-8-0 and 4-6-0, the USRA designs, and the Lima logging and industrial engines. Of the three major builders, Lima was probably the most avid supporter of design standardization with American a very close second. Baldwin advocated quite the opposite approach, making custom machines into the diesel era.

Lima's standardization philosophy, born in its logging days, would now be applied to its first proprietary mainline design. Because the NYCs dimensional constraints were among the tightest in the country, the new locomotive would be designed to them. If it would fit on the east end of the Central, it would fit just about anywhere. Lima also was acutely aware that the NYC was still its largest account and was very interested in the development of the new design, but now the collaboration was based on equal terms.

On September 27, 1924, order #1070 was entered on record for one 2-8-4 steam locomotive "for stock" at Lima, Ohio. This shop order heralded the beginning of the last major phase of development of the steam locomotive in the United States.

With the data gathered from the H10, both technically and proprietary, the prototype was designed with the following features:

- The firebox size was increased to accommodate an unheard of 100 square foot grate area.
- A four wheel trailing truck was used to accommo-



Class A1a #1420 awaits service at Beacon Park. NYCSHS Purinton collection.

Class A1a #1421 eastbound near Riverside. NYCSHS Purinton collection.

date the resulting firebox. This particular design was unusual in that the mainframe was abbreviated just behind the rear driving boxes. The trailing truck was pinned to the frame behind the last driver set. Tractive force was transmitted to the drawbar through the trailing truck rather than through a full length mainframe. This created what Lima called an "Articulated Frame" in its literature.

Another reason for the use of this rather unusual trailing truck/frame arrangement came as the result of the much longer distance between the last driving axle and the drawbar location. It was felt that the use of a full length frame and a truck such as the Commonwealth design would result in an undesirable degree of lateral displacement of the drawhead while negotiating common curvatures resulting in undesirable lateral loads on both the driving boxes and the tender connection.

• The ashpan was placed on top of the trailing truck, not attached to the bottom of the firebox as in conventional practice. This allowed for a larger pan capacity, one cubic foot per square foot of grate, and much improved draft into the firebox.

A 65% cutoff limit was proposed with a boiler pressure of 230 psi. A booster engine on the rear axle of the trailing truck was also incorporated. The limited cutoff feature with an accompanying increase in boiler pressure was a fuel conservation technique which was reputed to work well at track speeds; however, it had a detrimental effect on starting performance. The booster was included to counter this effect. By the time the prototype was completed, the cutoff limit was further reduced to 60% with a proportional increase in boiler pressure to 240 psi.

• The boiler itself was the first applied to a locomotive that could theoretically produce more steam than the cylinders could consume.

• The tandem rod arrangement differed from established practice. The driver end of the main rod was forked and surrounded the knuckle of the last section (between the main and #4 driver) of the side rod on the main crankpin. The last section of the side rod, therefore, became an extension of the main rod and served to split the thrust loads from the cylinders between the main and #4 pins instead of concentrating those loads on the main pin as in previous practice. The remainder of the side rod assembly (between the main, #2,and #1 drivers) was attached to the main crankpin inboard of the previously mentioned assembly.

• The steam chest assembly, or "cylinder saddle", was cast in steel with two pieces bolted together with the steam passages bolted on externally. The cylinder liners themselves were separate iron sleeves. This saved some 4000 lbs. of dead weight from previous practice and was still stout enough to accommodate the higher steam pressures expected. The axle loading limits previously reached caused great concern with useless weight, and in this case the savings was reinvested in increased boiler capacity.

Features brought forward from the H10 included the smokebox or front end throttle, Elesco feedwater heater, Baker long travel valve gear, and the Type E superheater. An important feature not brought forward from the H10 was the use of only a single flue size. Reverting to the older tube-and-flue arrangement yielded a 15% increase in gas area with a corresponding improvement in boiler efficiency. Also notably absent was a combustion chamber, whose worth was apparently not yet fully understood.

By February, 1925, the new locomotive had an appointment with the Lima photographer, resplendent in black paint, lettered for the Boston and Albany, and numbered 1.

In February, 1925, Lima 2-8-4 #1 arrived in Selkirk to begin road tests over the B&A. A wooden windscreen was fitted on the pilot to house test equipment and the attendant technician and, with the addition of NYC dynamometer car X-8006 testing was ready to commence on March 28, 1925. The testing of #l on the B&A was limited to the Selkirk-Springfield portion of the mainline which included the ruling grade (1.65%) to the summit of the Berkshires at Washington, Mass.

The most recounted trip during the test period occurred on April 14th. The test section chosen was a 47 mile portion of the main from Selkirk, across the new A.H. Smith bridge over the Hudson, up the grade (.95% ruling) through Richmond, Mass. to the North Adams Jct. yard in Pittsfield. Not only was this a test using the X-8006 to record data, but it also included a head-to-head competition with a representative of the current state of the art, Alco H10 #190.

#190 left Selkirk with 49 cars (1691 tons) at 10:57 AM. #l departed at 11:44 with 54 cars (2296 tons). #1 passed the new HlOb at Canaan, N.Y. only 26 miles from Albany and arrived at North Adams Jct. ten minutes ahead of #190. The new engine moved 35% more tonnage reducing the elapsed time over 47 miles of railroad that could not be characterized as "Water Level" by any stretch of the imagination by almost an hour. The H10 was obsolete.

Although this performance was indeed spectacular, the real story lay in the results of the dynamometer tests. Before the actual testing began, the projected performance was modeled using the long established Cole's ratios. This model originated at the engineering department at American way back in the tractive effort days. Cole's model had been long considered to be conservative, but the April test results now proved the established model itself to be invalid for modern locomotive design. As of April,1925, there was only one truly modern steam locomotive in the country.

The new locomotive left the B&A by June with a new name. Lima #1, the first 2-8-4 Berkshire type, went on a tour across the country demonstrating the virtues of "Super Power", and left the NYC to consider their next move.

American had hardly been idle during this time and. one month after the Lima prototype saw daylight, 4-8-2 #2700 began tests on the Central's mainline between Albany and Syracuse. Although the new Mohawk lacked the heating area of the Berkshire, it did have many of the same modern accessories. It, too, was a clear step forward over its predecessor, the L1. It should be noted that the Berkshire was the superior design for the tight curves and frequent grades found on the B&A where speeds rarely exceeded 40 MPH. The new Mohawk, class L2, was a locomotive designed for flat, straight railroading where the reduced heating area was not such a disadvantage. In addition, the L2 had 69" drivers compared to the Berkshire's 63 inches. The larger driver diameter was easier to balance and therefore could revolve faster before having problems with dynamic augment or wheel lift. Additionally, the L2 travelled faster than the Berkshire at equal wheel RPM's due to having

Class A1b #1425, the first of that class, ready for service at Beacon Park, November 1936. NYCSHS Purinton collection.

Also photographed at Beacon Park in November 1936 was class A1b #1431. NYCSHS Purinton collection.

larger drivers. Unfortunately for Lima, the L2 was the superior design for the type of railroad that was the Water Level Route. The B&A, however, was anything but typical of the NYC.

THE FIRST ORDERS

On October 21,1925, order #1082 was placed at Lima, Ohio for 25 2-8-4 Berkshire type locomotives, class A1a, for the Boston and Albany Railroad. The first 14 of this order, 1400-1413, left the plant in February, 1926. The remaining 11 locomotives, 1414-1424, followed in March.

The most obvious difference between the A1a for the B&A and the original #1 was a two ton increase in engine weight and the use of the smaller 16 ton, 10,000 gallon tender instead of the larger six-axle, 18-22 ton, 15,000 gallon tank that was behind the prototype. Both of these tender types were standard to the NYC Lines and a myth regarding the choice of the smaller tank will be discussed later. The water capacity of the chosen tank was reduced in this application to 9600 gallons, possibly to make room for the stoker engine. Because of the abbreviated mainframe, the stoker engine could not be mounted in its normal location under the cab.

The five months between April and August provided some operational experience with the new power that resulted in some changes in the design when order #1095 was placed for twenty A1b Berkshires. The original sandboxes, although larger on the A1a than applied to the Lima prototype, were still found to be woefully inadequate. Because of the rather low factor of adhesion of 3.6 (4.0 is the preferred) and the compromised starting performance of limited cutoff, sand capacity became of paramount importance. The Alb was built with an unbelievably huge, rectangular sandbox to rectify the problem. The earlier Ala subclass was quickly retrofitted with an identical box. It is unknown whether an A1 ever went through a Berkshire winter without one.

Another change was made with regard to the method of powering turret accessories. On the A1a, a pipe was run from the superheater header to the fireman's side of the turret to supply superheated steam to the accessories. This did not prove to be an advantage and the pipe was not used on the A1b. The turret on the A1b was supplied with saturated steam instead. The A1b also featured turret covers and reverted back to the original engine weight of the Lima prototype.

With the delivery of A1b #1425-1444 starting in December, 1926 came changes in the roster of the Boston and Albany. The H10s were displaced to the CCC&StL and the Z-type 2-10-2s were sold to the Canadian National. Both classes were extinct on the B&A by the end of 1928.

THE TENDER MYTH

It has often been published that the A1a and subsequent A1b classes had originally been built with the larger tanks; however, they had been removed by a covetous NYC as they passed through West Albany and replaced with the smaller tenders because of inadequate turntable lengths on the B&A. This is not valid. Published photographs from Lima's archives now in the possession of the Allen County Historical Society clearly show two new 4-axle tenders in the Truck Shop at Lima, numbered 1417 and 1418, in the company of trailing trucks and ashpans for coal-fired Super Power type steam locomotives. The only ones under construction at the time fitting that description were for the B&A. Another set of photos in the same collection, taken in the Paint Shop at Lima, depict two cabs being painted in the company of four tender bodies. One cab is numbered 1423 and the tanks are clearly 16 tonners. These photos clearly show, along with the class "builder's photos", that the first two subclasses of B&A Berkshires left Lima with the smaller four-axle tenders.

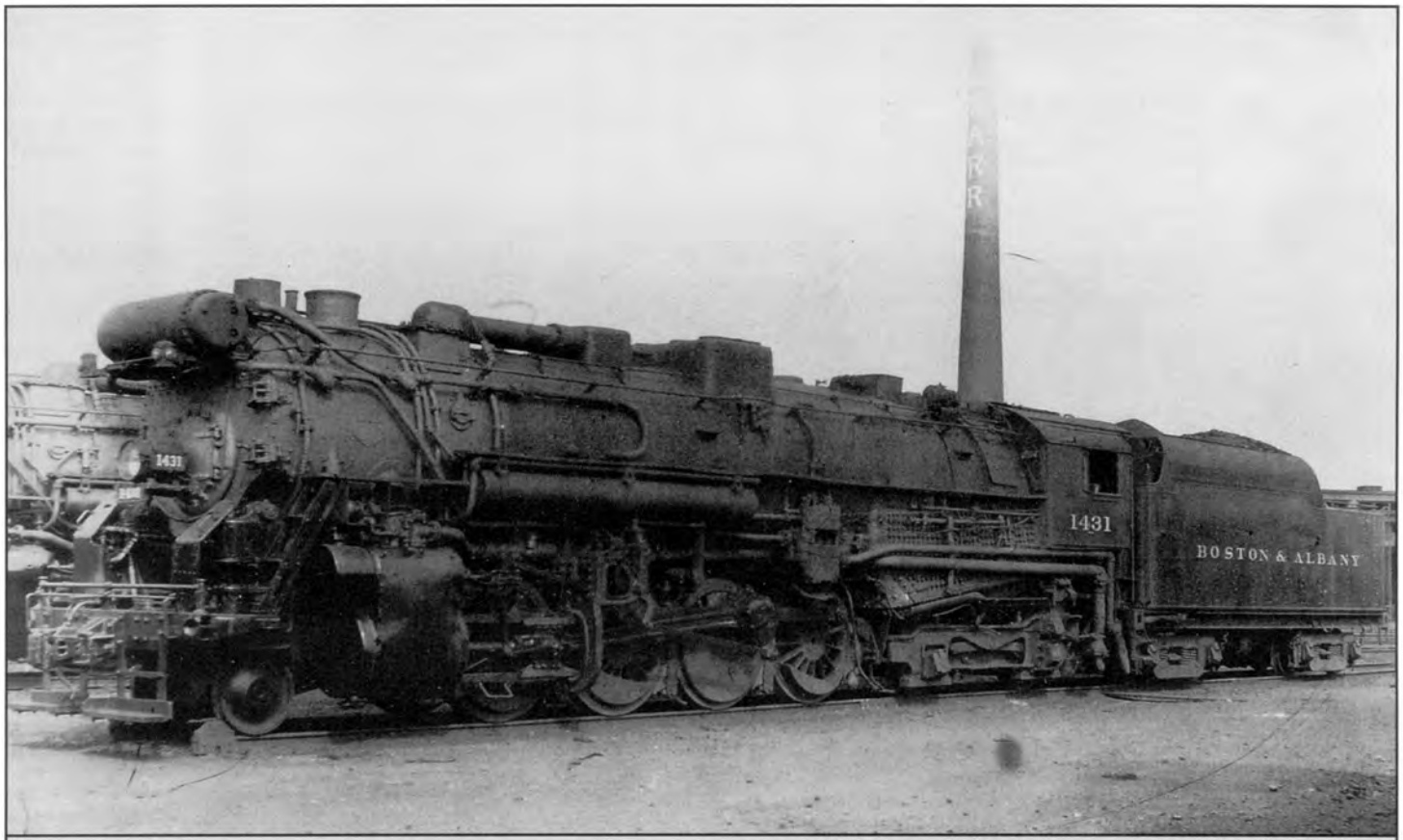
The other interesting aspect of this assumption is that the wheelbase of the locomotive and tender was supposedly too long for the existing turntables using the larger tanks (82'6" vs 75'9"). The story is further told that the parent NYC replaced the offending turntables with longer ones in the 1940s when it took "operating control" of the B&A. Without knowing the actual turntable lengths in question it can safely be assumed that, because the Lima #1 could be handled successfully between Selkirk and Springfield with a 82'6" wheelbase, this was not the case on the western end of the railroad. Further, when the last class of A1 was delivered in 1930 with the larger tank and a 82'8" wheelbase, there was no mention in the employee timetable that such a turning restriction occurred on the eastern end. Therefore, any change that may have occurred to the turning capabilities of the physical plant would have taken place before 1930, east of Springfield, not "in the 1940s under NYC control" (which was little different from the 1920s).

The most reasonable explanation for the choice of tenders probably lies in the fact that intelligent people chose the smallest (therefore the lightest) tenders available that satisfied the requirements for capacities and range. Anything heavier would waste pulling capacity. By the time of the last order, it was determined that the early tenders were only barely adequate and the larger type was ordered with the A1c. The tenders were also replaced on several examples of the Aa and A1b during their service life with tanks from J1b and c Hudsons as operating requirements changed. Another A1a, 1400, received a six axle (18/22 ton) freight tank, presumably from an H7 or H10, at the same time. It is interesting to note that the same decision was made when the J2 Hudson types were ordered. They were also delivered with the 16 ton tender rather than the familiar 24/28 tonners of their NYC brethren, probably for the same reasons.

THE A1C

On February 5, 1930, order #1123 was placed for ten 2-8-4 types to be class A1c. 1445-1454 were shipped in August. The locomotives were mechanically similar to the previous A1 types, but visually they were quite different. Along with the larger tanks previously discussed, the A1c featured a Coffin feedwater heater instead of the Elesco of the earlier classes. Also, the troublesome trailing truck arrangement of the A1a/b was eliminated in favor of the Commonwealth two-axle trailer and full length frame as in the J1 Hudson. The Standard stoker was used in lieu of the flawed Duplex stoker, a modification made to the A1a/b as well. The prominent external dry-pipe and protruding superheater header were eliminated, replaced by a flush mounted header and internal dry-pipe. The engine weight increased by 11,000 lbs to 396,000 lbs. The result was a much more elegant appearance and a nickname of "Sports Model"

With the A1c, the B&A had acquired its total of 55 Berkshires. This allowed for the dismissal from the



Almost three years later, on August 23, 1939, George Votava caught #1431 at Beacon Park once more. Europe would have only eight more days of peace.

Another Beacon Park photo, this time of class A1b #1436. NYCSHS Purinton collection.

roster of the NE articulateds. Because of the early effects of what was to become a world-wide financial disaster, a buyer for the large slow 2-6-6-2s could not be found. By 1932, they went for scrap.

LESSONS LEARNED

The B&A had direct benefit of Lima's designs; however, the NYC also benefited in a more indirect way. The concept of "Super Power" had been proven to be an important improvement in locomotive design. Although the A1 (and a parallel 2-10-4 design) were proprietary designs, a concept is not likewise protected. Kiefer and the NYC were quick to capitalize on this and, in concert with American, applied the concept to the 4-6-2 Pacific in much the same way as Woodard had applied it to the 2-8-2. The result was the excellent 4-6-4 Hudson type which became the mainstay of System passenger power until the advent of the Diesel.

On the freight side of the house, the story was quite different. American's L2 Mohawk proved to be superior to the A1 for high speed freight service on the Central's mostly gradeless mainline. Kiefer elected to remain with the 4-8-2 wheel arrangement until the Diesel era. It would fall to other railroads and engineering dynasties to refine the "Super Power" freight locomotive to its fullest potential, namely the Van Sweringen roads (C&O, Pere Marquette, Erie, NKP).

THE A1

The A1 was a leap forward in locomotive design, however, as with all new developments, there were things to be refined.

• The Articulated Frame: The trailing truck was prone to derailing while backing up at speed or under load through switches. As the tender curved through a reversed switch, the lateral force through the drawhead increased, pushing the flange of the rear wheelset of the trailing truck to the outside of the curve. Any flaw in the point closure or frog would result in the wheel climbing the outside rail with interesting results.

Because the frame was short in this arrangement, the waist sheet was prone to being over-stressed. In "normal" design, the cab and firebox are attached to both boiler and frame. In this case, there was no frame for the cab or firebox to be attached to. These parts were cantilevered off the waist-sheet instead, with chafing blocks on the trailing truck to take some of the load. In extreme changes of vertical track curvature, the weight of the firebox and cab would be totally taken up by the waist sheet at a "peak", or by the trailing truck blocks at a "valley". This would alternatingly compress or stretch the waist sheet as well as put significant variable loads at the mud ring.

An additional problem encountered with the trailing truck arrangement was that, because the ashpan was placed on the truck itself, the draft would vary significantly as the truck swung in a curve or gradient change. Under certain circumstances the draft would become so excessive that it would actually lift the fire off the grates.

The problems with the articulated frame were remedied by elimination and replacement with a full length frame and Commonwealth trailer, first by American on the C&NW 2-8-4s in 1927. The last Berkshires built with the articulated frames were for the B&M (T1b) in 1929. The B&A A1c subclass was built without this troublesome arrangement the next year.

• Grate Area: The 2-8-4s for the B&A were all built with 100 square foot grate areas. In later improvements, most notably in the Van Sweringen Berkshires, this was reduced to 90 square feet with no detrimental effect.

• Limited Cutoff: This feature was one of the most controversial. Some accounts praise its use for fuel economy while others vilify it for the loss of starting power that was an inherent flaw. Since the early Lima Berkshires had a less than desirable factor of adhesion, the starting difficulties were aggravated. The B&A eventually removed the limited cutoff from its Berkshires and lowered the boiler pressure accordingly. The concept of limited compensated cutoff quietly went the way of the three-cylinder locomotive industry wide.

• Feedwater Heaters: Although the NYC used Elesco and Coffin feedwaters (Elesco as late as the L3b's in the early 1940s) clearly the Worthington Type was superior in that it did not lose its effectiveness due to deposits on the heat transfer surfaces. The Worthington open type introduced exhaust steam directly to the feedwater.

• Driver size: Although the first Lima 2-8-4s were a revolution in locomotive design, this was the first limitation that was encountered in the original design. The 63" driver was carried over from the NYC H10 project as a standard size into the 2-8-4 project. Although it was probably the best choice for a railroad like the B&A, it was too small for the higher speeds required by other roads or the NYC itself. Had the early Berkshire been built with the 69" Mohawk driver, the story could have been very different with the NYC being the road that brought the concept to its zenith instead of the Van Sweringan roads. Although the Erie demanded the 70" driver on its ALCO Berks in 1927, Lima did not pick up on the 69/70 inch driver as a standard feature on its Super Power locomotives until perfecting the Van Sweringen Berkshires in the late 1930s. These engines combined the best features of the American, Lima, and Erie designs. The 63" driver was not one of them.

Lima was acutely aware of the reaction by the NYC to the new design. The numbers spoke volumes. The Central bought 55 Berkshires for the B&A compared to 300 L2 Mohawks for the remainder of the system. The Central's relationship with Lima underwent a noticeable change as well. Orders throughout the remainder of the steam era were for NYC design tenders and modified American designs such as the J2c Hudson and the L4 Mohawk. The Central, who turned out to be the "Super Power concept's strongest adherent with 365 examples, never bought another steam locomotive of Lima design.

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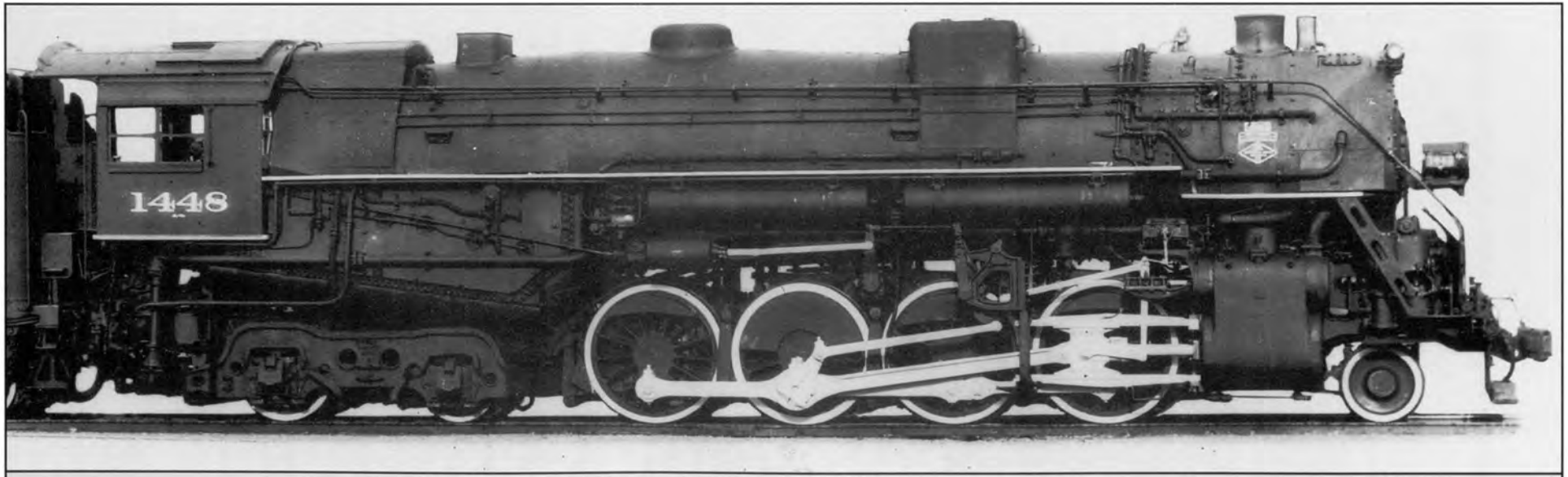
Class A1c #1449 at Beacon Park in November 1936. NYCSHS Purinton collection.



Class A1c #1448, fourth of the third and last group of B&A Berkshires, in a builder's photo.
These engines were delivered in 1930. NYCSHS Purinton collection.

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NYCS Drawing #5085 (B&A Track Diagram)

B&A Employees' Timetables

Class A1c #1452 at Beacon Park on July 10, 1937. The "B&A RR" stack in the background stood until the 1960's. NYCSHS Purinton collection.