TO: Dr. E. L. Goldwasser and Dr. A. L. Read

FROM: W. W. Salsig

SUBJECT: Observations on Various Features of NAL Experimental Area Proposals

At the request of Drs. Goldwasser and Read, I spent from 3:00 PM, Tuesday, September 5, 1967 through the afternoon of Friday, September 8, 1967 at the National Accelerator Laboratory in Oak Brook. Approximately 2/3 of the time was spent on considerations affecting the experimental area. During this time concepts for three different styles of experimental end stations (NAL Stations A, B, and C) were being brought to focus by many staff and visiting physicists. Conceptual ideas had jelled, and specific beams, shielding proposals, and station lengths were being established, and I was asked questions on building and crane coverages, etc.

The conceptual ideas, which appeared to be reasonably firm, proposed the three following types of target stations:

<u>Type A</u> - A modified "internal target area" style of station, where the primary EPB passes through relatively thin targets and provides practically all the features of a true "internal target" station, except that of multiple beam traversal. This station would generate relatively less radiation than types B and C and would be more flexible in set-up than C, but less than B. Presently envisoned were earth-covered beam lines downstream of the target, possibly with relatively vertical concrete walls forming a bin, which gets away from the long toe of an earth berme.

<u>Type B</u> - This station would be the most flexible. Presumably it would incorporate the largest number of secondary beams (12 were being considered) and would be the most subject to change. The very massive shielding to stop muons would not be present -- this radiation

would pass out of the target region and eventually into earth. It would not be possible to obtain neutral secondary beams from this station since secondary lines must clear the "muon to dump" channel.

Type C - This would be the most massively shielded station, stopping muons immediately after they are generated. Neutral secondary beams would be available here, plus 2 to 3 other high-energy channels which are expected to be stable in set-up over periods of years. Target station shielding is expected to be in the range of 24,000-30,000 tons, mostly of iron. (As a comparison, although not strictly identical, the "Blue Book" long EPB channel had approximately 85,000 tons of shielding.)

Mechanical Considerations Discussed

1) Can the two proposals for the EPB and the Internal Target and Construction Staging Area be made almost identical? In fact, can all of the 6 buildings over the long straight sections be made the same?

Figure 1 and Figure 2 on the following page show the existing proposals.

It appears to the author that they can be combined into a common structure style, as shown in Fig. 3, which increased the flexibility possible for the EPB exit. If the branch tunnel is made to junction with the main building, and the collimator effect obtained by an arrangement made such as shown in Fig. 5, (instead of earth fill around a small pipe as in Fig. 1), one has future flexibility. If, several years after starting, it is desirable to put different beam transport elements in, they can go anywhere and the tunnel plug can also be repositioned. A further advantage is that the outside radius railroad can be made continuous down the EPB tunnel.

INITIAL STUDIES

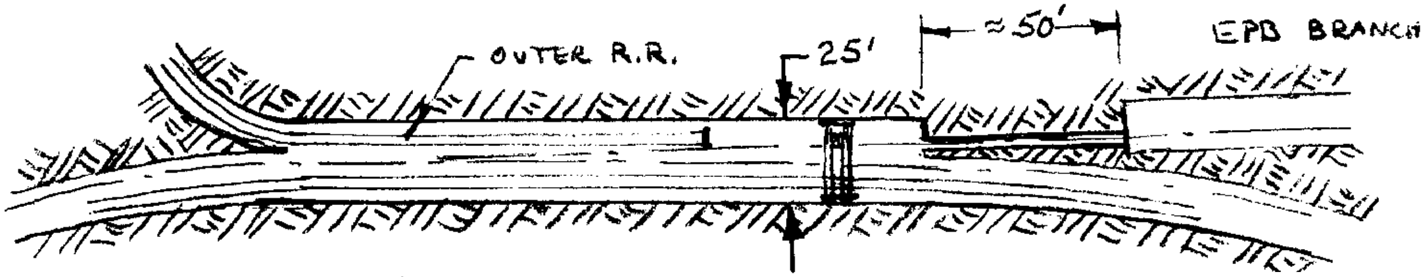


FIG 1 EPB BRANCH

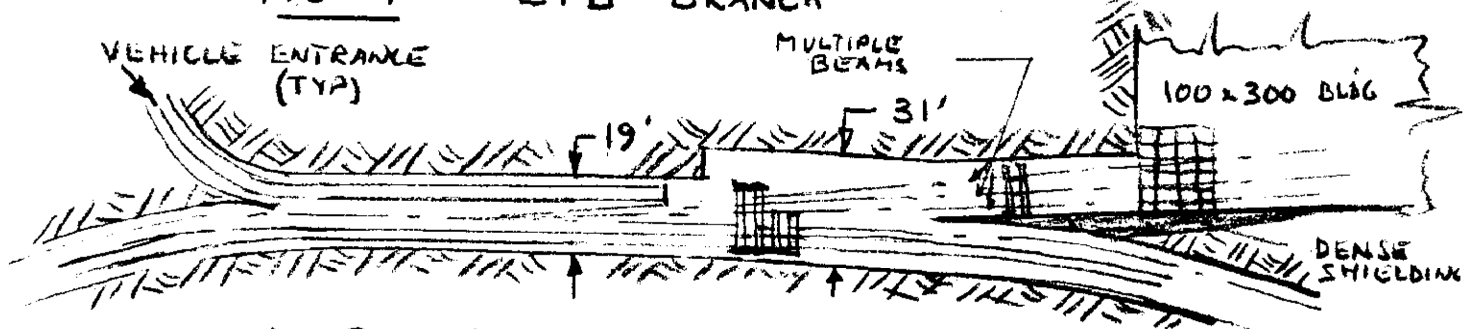


FIG. 2 INTERNAL TARGET & CONSTRUCTION STAGING AREA.

SUGGESTED COMMON SECTIONS

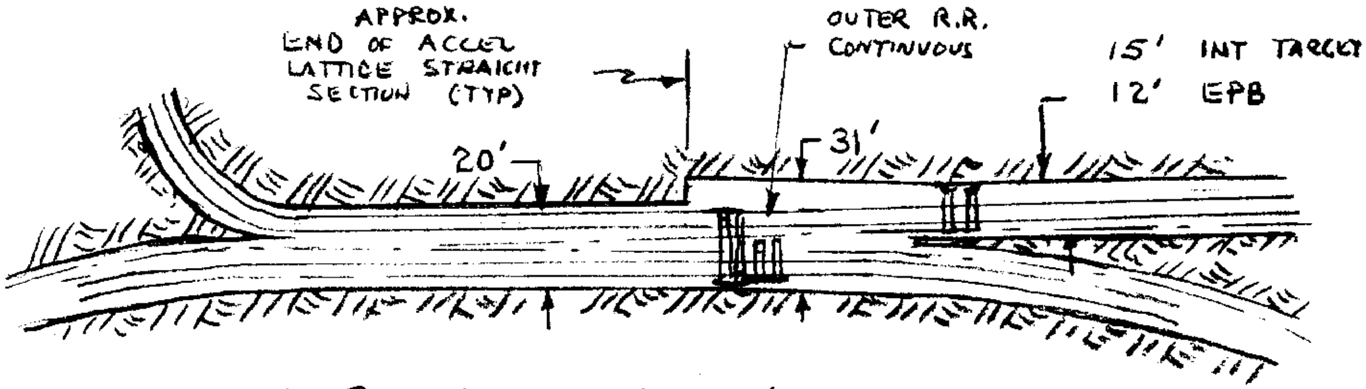


FIG 3 COMMON SECTION - TWO WIDTHS

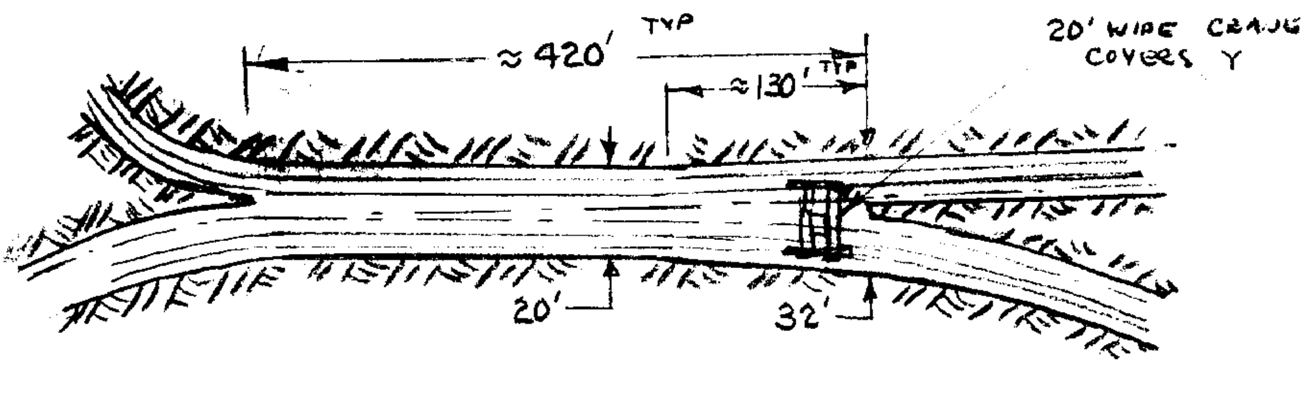


FIG 4 COMMON SECTION - TAPERED EXPANSION
(J. MACRONALD - DUSAF)

Costs for implementing Fig. 3 in place of Fig. 1 and Fig. 2 would be little changed.

	Fig. 3	Fig. 1
1) Floor Area - Main Building	≈ 10,000 ft^2	10,500 ft^2
2) Cost at $ ft^2 of Floor Area (source - D. Mapes (DUSAF))	$280,000	$294,000
3) Additional Tunnel 60'x $280/ft	$17,000	
4) Cost of Hand-Placed Backfill around 60' Beam Line (Fig. 1) 60/3 x 4 yds high x 5 yds wide x $5/$yd^3$		2,000
5) Tunnel End Walls - 30 yds at $70		2,100
6) Movable Modular Plugs in EPB Tunnel	≈ 40,000	
	$337,000	$298,100
Approximate Difference	$39,000	

A further interesting scheme was shown to me by MacRonald of DUSAF just before I left, as shown in Fig. 4. This envisions a tapering widening of the last 120 ft of the long straight section, instead of the abrupt widening of Fig. 3. Both outside and inside radius railroads are identical with Fig. 3. The one 20 ft wide crane services the Y area quite well and a branch crane from the internal target tunnel can be interlaced with the main building crane if it is the underhung style, but without the trolley transfer feature. This scheme reduces the main building floor area from 10,500 ft^2 scheme in Fig. 1 to approximately 9,100 ft^2, for additional cost reductions of approximately 900 x $28 = $25,000 per station over Fig. 3 scheme

The choice for scheme 4 (Fig. 4) rests on DUSAF'S ability to economically make cross-beams of many different lengths, compared to just two for Fig. 3, and the value the operating people would place on the usefulness of an inside storage alcove with crane coverage which comes as a byproduct of Fig. 3.

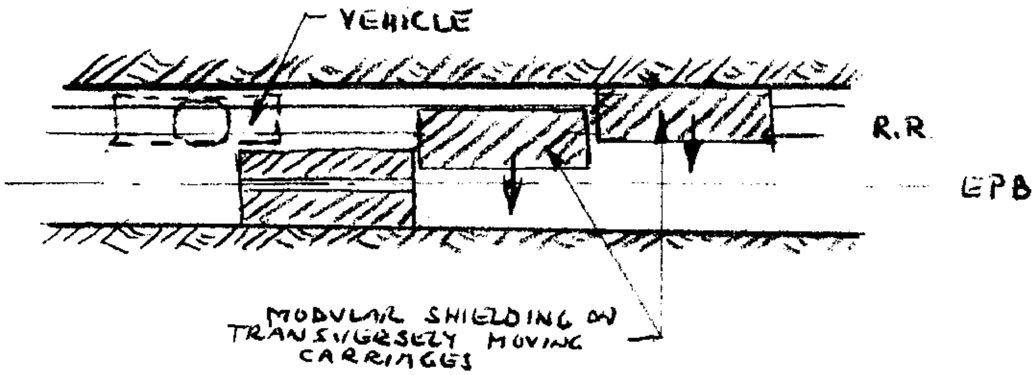


FIG 5 BRANCH TUNNEL RADIATION PLUG ALLOWING VEHICLE PASSAGE
(PLUG OF MODULAR SHIELDING AND IS REPOSITIONAL ALONG TUNNEL)

Before leaving the discussion of the long straight section buildings, a wild idea should be mentioned with respect to the initially "unused" ones -- will there be 3? If some scheme could be found which would cut down the initial cost, and the full building be recovered by future cost at a time when it was needed, without massive reconstruction, the savings might be attractive. If columns are allowed at

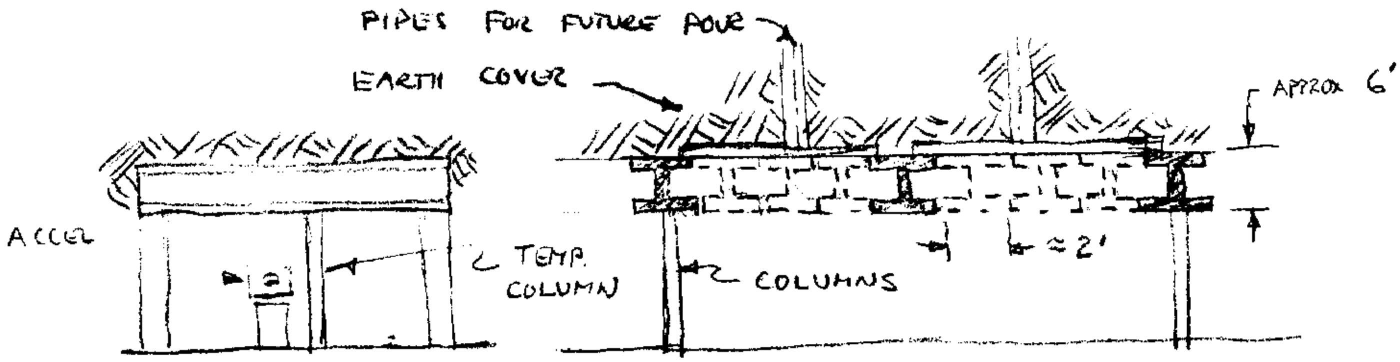


FIG 6 TEMPORARY COLUMNS TO ALLOW INITIALLY LIGHTER CONSTRUCTION IN UNUSED STRAIGHT SECTIONS

midspan on the roof support beams, the span is halved and the stress reduced a factor of approximately 4. So, perhaps only each 4th beam needs to be used. Spanning panels overhead would support the earth.

When the unobstructed area needs to be recovered, the space between the beams could perhaps be poured with concrete from previously placed pipes, and the columns could then be removed. Some equivalent scheme could be postulated for the floor.

The important feature is that columns, which might not be much of an impediment when buildings are "in reserve", would greatly reduce the job required of the overhead and floor beams or slabs. This scheme has been rougly outlined to Ross Dowdy, DUSAF Structural Engineer, who got a gleam in his eye but said little more than "people are always trying to make life harder for the Structural Engineer". Perhaps he should be encouraged to think about such a scheme on his own terms.

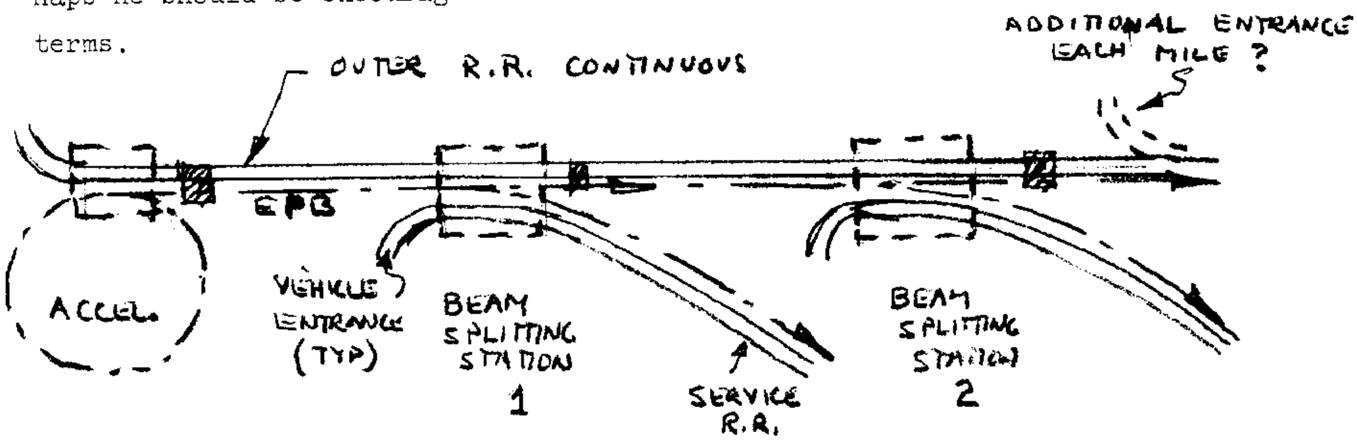


FIG 7 RAIL SERVICE FOR EPB BRANCH LINES

With main building arrangements as suggested, the service railroad down the outside of the long EPB could be continuous. Branch lines could be introduced at each beam splitting station on the "inside radius", so that each splitting Y would have some servicing capability as Main Ring Buildings.

At Target Stations on the split branch line the scheme would be opposite hand.

Dr. Mashke believes the main transport tunnels will be relatively quiet with respect to residual radiation -- unshielded men could be expected to work there. The beam transport line may be shielded by perhaps a few inches of iron, split cylinders that would nest around the vacuum pipes. Magnets will be infrequent (100' to 400' apart), vacuum pumps will be present and various beam position monitors and radiation detectors. The railroad would allow use of the streetcar type Work Center Vehicle (a traveling tool room, light and electric power center) or, in case of a residual radiation embarrassment, the Shielded Manipulator Vehicle could also be introduced.

The author believes provision should be made to provide at least light overhead crane service. This would envision a precast tunnel section two feet higher than presently proposed for the accelerator as a very minimum. Magnet components would be installed or replaced by the side-handling trucks proposed for the accelerator. The crane should be of the order of 3-ton capacity minimum and would be the superior system for working with all loads of 3 tons or less -- shielding around the beam tubes, temporary developmental equipment. The cranes should be portable, brought in with the work crews, and be capable of rapid erection from a mast on the rail vehicle. For specific jobs they would probably be used locally over ranges of 50 to 100 ft, and hence could operate from plug-in electrical outlets. For economy it is not inconceivable that such short lengths of rail could be brought in and erected at the work site to modularly-placed supports in the tunnel shell by the same vehicle transporting the crane. Or the crane rails may consist of electrical conduit used for utility distribution. The superior features to be preserved are the very real ease and precision with which a pendulum load can be guided by hand in the horizontal plan, and the ability of the handling devices to move independently with respect to the rail vehicles.

2) On those straight section buildings which will not be initially implemented as external beam outlets, how far should the branch tunnel be extended at initial construction?

With the position monitoring and adjustment system proposed for the accelerator, it is presumed the capability exists for quickly recovering from any disturbance which might result from close-in earthwork. Therefore, this is not a restraint.

It is presumed that the most likely action in activating a reserve beam station would be to extend the branch tunnel section rather than to construct an earth bulkhead or retaining wall and then a large building or slab area.

The least restraint on future construction would be obtained if such work could be undertaken even though the accelerator is operating.

From these considerations it appears the quantity of shielding required between the accelerator and the future construction work is the principal criterion. If this is to be taken as the canonical 30 ft of earth, the branch tunnel extension would need to be approximately 240 ft long, as measured from the junction of the branch tunnel with the straight section building and as scaled from the MK·III Internal Target Section drawing. If the precast tunnel elements cost $280/ft, this would amount to $67,000 for the structure or the order of $80,000 with the earthwork as well. To re-establish construction, sheet piling would probably be driven down through the earth on both sides of the branch tunnel right-of-way and formed into a braced-cut operation. This would allow a vertical wall on the accelerator side to preserve the 30 ft of sheilding. (DUSAF should be consulted as to whether superior options exist.)

If heavy aggregate, for example barite at 220 lbs/ft^3, were used between the accelerator and branch tunnels, the branch tunnel length could be decreased to approximately 120 ft in length which would reduce costs $40,000. However, with barite aggregate installed

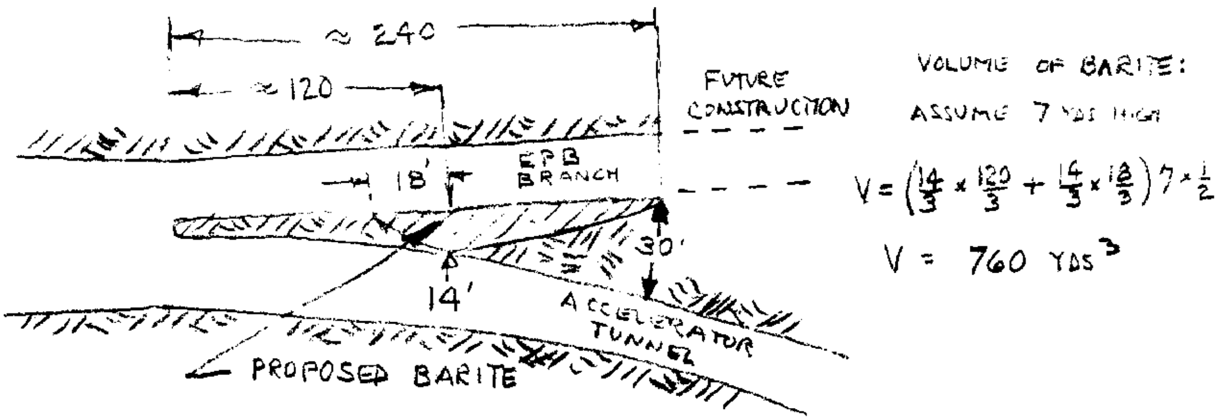


FIG 8 - REDUCTION IN BRANCH TUNNEL LENGTH BY USE OF HEAVY AGGREGATE TO SHIELD FUTURE CONSTRUCTION SITE

7 yards high, 760 yards^3 would be required which is $84,000 at $110/yd^3 in place. This certainly is far from a net savings in initial cost, even though the barite, worth approximately $95/yd^3, might be usefully salvaged after the tunnel extension.

A variation on this concept would be to place the heavy shielding at the start of construction of the tunnel extension. Let us assume a well-drilling rig can be operated from the top of the earth fill. A close pattern of holes, perhaps 3 ft in diameter, could be put down and filled with a mixture of compressed junk automobiles and barite aggregate as soon as they are drilled. Perhaps light-gauge steel hole liners would be required because of the closeness of the hole spacing. Two advantages arise immediately, (1) the heavy materials would not be incorporated unless the station were actually going to be brought into service and (2) a very good evaluation of the quantities of heavy materials required would be available from actual measurement of the radiation being generated from accelerator operations. This approach would undoubtedly be the most expensive overall, but practically all charges would be future costs, and only 120 ft on the branch tunnel would be initially required. This would reduce initial costs to approximately $40,000 from $80,000.

Two other options may possibly be considered: (1) Burying a large pipe (2 ft to 4 ft in diameter) for the first 240 ft, which would cost $6,000 to $10,000 instead of $80,000 for the tunnel, but builds in a discouragingly inflexible start for any future experimentat station, or (2) constructing the 240 ft tunnel branch during a shutdown for which probably not less than 6 weeks would be required , assuming the tunnel sections are precast before the shutdown.

From this spectrum of alternates, the second is most appealing to the author -- build 120 ft long branch tunnel initially. Add dense shielding between the accelerator and the branch work site in the future if this construction is to be done while the accelerator is operating. If only one of three stations is eventually implemented, this will also be the least expensive overall option.

3) What type of buildings and handling facilities should be provided at and downstream of the target stations?

Before discussing individual stations the elevations intended for such stations are of interest. The tentative decision, now rather firm, is to establish the accelerator tunnel floor at 725 ft and to maintain the single,straight and very long EPB "distribution" line at approximately the same elevation. Having this tunnel buried gives considerable facility for communication and utility distribution (roads and rights-of-way) over this line to the target stations, secondary beam lines, and experimental equipment end stations. Primary utility distribution to the experimental areas is expected to be along this line, with branches to the various stations.

After each beam splitting station along the primary EPB line, the branch line for the target station will rise to, or very near, the surface which is approximately 740 ft elevation. In this way the target stations and secondary beam lines will be essentially at the surface and avoid the very real problems, such as flood control, awkward access, secondary line restriction dur to sides of the hole, etc., which would arise if the experimental areas were kept at or near the accelerator elevation in large "Glory Holes".

For Target Station C, which will have the most massive shielding and relatively time-stable secondary beam lines, a conventional building and handling system seems most appropriate.

Present NAL studies envision high density (predominantly iron) shielding totaling approximately 25,000 tons in a sort of target station lamp. This could possibly be housed in a building 125 ft wide x 200 ft long. This shielding then transitions into lighter modular shielding for perhaps another 200 ft before the secondary beam lines are really distinct and separate.

The big lump of target shielding poses unusual problems. The internal regions will undoubtedly become signifcantly radioactive. Although no specific radiation models exist either from the LRL or the NAL work for this region, it will certainly be factors higher in residual radiation than the most troublesome spots on the accelerator. Thus, during periods of rearranging secondary beams or maintaining target station components, much of the shielding will have to be handled using special precautions. Let us presume that after the outside layers of shielding are removed the balance can be handled by protecting the crane operator with a shielded cab -- a special addition to the crane which would weight 30 to 40 tons. Fortunately for initial costs, this cab may not have to be procured untial a year or two after the start of initial low intensity operation.

Even if only a small proportion of the target shielding needs to be unstacked for maintenance or a beam line change, the amount of material to handle is staggering. Let us say 1/5 of the total will be moved -- 5,000 tons. If an operator in a crane can handle 6 blocks an hour averaged over a shift, which would change very little whether he was handling 10-ton or 50-ton blocks, it is immediately apparent that the total number of lifts required should be a minimum. If 50-ton modules are supplied, approximately 4, 8 hr shifts would be required to unstack and restack 1/5 of the station. If 10-ton modules were used, two weeks would be required.

All precautions should be taken to keep such handling operations uncomplicated by foreseeable problems. For example, the foundation should be very stable so that differential settlements do not bind the blocks together. The best solution would be to support the target shielding pad from bedrock.

Again, Brookhaven has had troubles with blocks freezing together. For this region it would appear worthwhile to house the shielding in a building and heat the building sufficiently to take the chill off -- maintain perhaps 40°F. Like shipyard lofts, it will probably be found extravagant to maintain such a large building comfortably for people at all times, and keeping the chill off plus spot heating for peopled areas will be the economic answer.

Since the time consumed in rearranging the target station will be largely a function of the handling efficiency, a conventional top-riding crane is the national choice. This is particularly true where the shielded cab is required, which would add an unusual 40-ton traveling load.

The most efficient use of the crane will result if practically all of the load transport is done using the trolley motion rather than bridge plus trolley. Thus, reasonably wide aprons are required on either side of the target station where the individual blocks may be set on trucks, or on the floor, to be picked up by straddle carriers, for transport out of the station. Before the 125 ft building width is adopted, layouts should prove sufficient space is available. Perhaps 140 ft or 150 ft width is more appropriate.

Whether the second 200 ft of lighter modular shielding needs to be fully housed is not quite as clear as for the main target station where maintenance can be required at any time. The chance of wanting to rearrange the secondary beam lines during the winter is probably not zero, in which case the building would be essential. To house it in combination with a 50-ton craneway would cost approximately $\$35/\text{ft}^2$ including house utilities or $1 million for a 150 x 200 ft building.

During shutdowns both the target shielding and the lighter shielding along the beam tubes would want to be rearranged almost simultaneously. The need for a second bridge crane over the second 200 feet then needs examination. Before doing so let us discuss the other principal target station.

Housing and Handling at Station B

Station B is to be the busiest, the most dispersed and the most often rearranged of the initial principal target stations. The large number of secondary beams (12 as an initial model), the great areal extent of the fanning out of the lines, together with a desire for real flexibility in placing such lines, discourages the concept of fixed permanent buildings over the inboard fanning sections.

The author believes a rather radical departure from the past concept of permanent buildings will be worthwhile here. A few exploratory sketches have been made by DUSAF's F. Johnson, but considerably more layout work should be done before one can say with conviction that a concept exists.

In brief, the proposal would be to meld the concepts of overhead tram cranes with that of "Space Frame" roofs. The two components are each developed and working, the possibility of combination is still "blue sky".

Tram cranes of 30-ton capacity are presently being installed in Boeing Aircraft's buildings at Everett, Washington for their 747 Air Bus production. These are very large clear-span buildings approximately 1600 ft x 500 ft in which the cranes are hung from the roof trusses.

"Space Frame" roof truss panels have been available for several years in increasingly large sizes. 100 ft x 100 ft panels are probably directly available, 200 ft x 200 ft certainly within the realm of possibility. These panels can be supported only at the four corners.

When considering them as support for underhung cranes, a deficiency can be immediately foreseen - the stiffness may be considerably less than would be essential. When a load is picked up the roof would undoubtedly vibrate with a slow period. This could be suppressed by occasional columns toward the centers of the spans. If these columns were movable, so they could be placed to avoid beam lines for each specific setup, the problem may be solvable.

The advantage which the space frame roof and underhung crane combination offers is the ability to temporarily expand in any direction and still maintain comprehensive crane coverage. Costs are vague at this juncture, but would certainly not exceed the cost of permanent buildings.

If further investigation bears out the promise of this concept, it is probably the appropriate solution to use for the second 200 ft of target station C.

The target region proper of station B needs further examination particularly with respect to a radiation model. If the residual radiation poses problems equivalent to those for station C, which is what one would expect, then the same type of handling would be essential - a heavy, traveling shielded cab for the operator on a top-riding bridge crane. One transitions to the space frame - under-hung crane concept just outboard of the target region proper.

Miscellaneous Comments

Utility Tunnels in Experimental Area Floors. At present 6 ft x 7 ft tunnels are being cast into the extension of the Bevatron experimental area. For these few hundred feet, costs are running $300/ft and the time to form and cast them in place greatly extends the overall construction period. Certainly precast sections would be investigated for any future extension of this area.

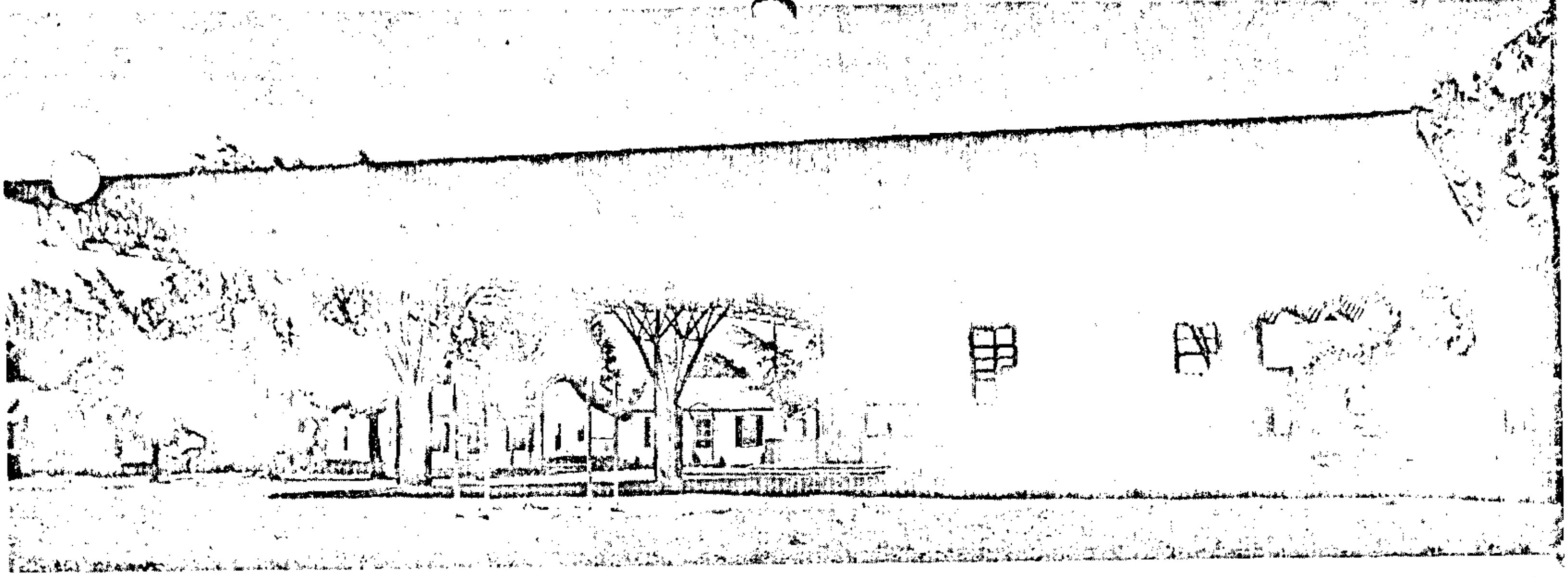
Utility Distribution. At load centers such as target stations it is undoubtedly appropriate to have a considerable portion of the electrical and cooling utilities as fixed installation. However, even here the greatest flexibility will result if a proportion is portable.

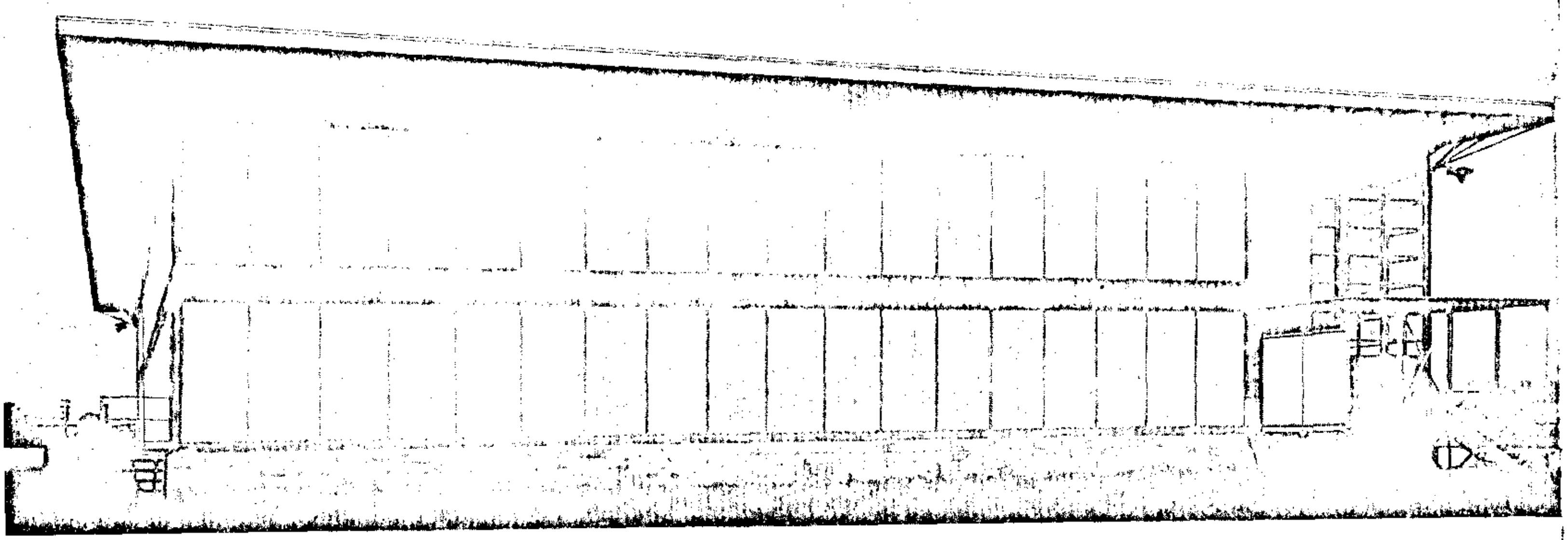
Along the rather sparsely populated beam transport portions of secondary beam lines, portable units would dominate. For example, a 13 kV electric service could be run on poles and transformers used periodically to service the loads. Rather small portable "cooling towers" greatly decrease the amount of water one has to circulate over long distances. Only the makeup water for evaporation losses need by supplied, which is perhaps 1/800 of the actual water circulated for cooling at any given area. For the larger loads at beam end stations a "semi-portable" concept exists. For example, BNL is now using 6 mW cooling tower on skids which, with some effort can be repositioned with occasionally changed large loads.

Secondary Beam Line Cover. Two concepts were depicted on NAL drawings: 1) precast concrete, or "wrinkled iron", tunnel sections covered with earth, and 2) modular concrete shielding covered with portable metal buildings. The later concept, which will probably require the greater initial investment, appears to the author to be much more flexible and less likely to generate future difficulties. Heaping earth in changing patterns will certainly frustrate any initial program of obtaining good drainage throughout the experimental area. The earth to cover the channels will have to come from somewhere, and the tendency will be to not go far enough, leaving sumps which will collect water, and in general keeping the entire region in a continuous state of construction - at times dusty, and sometimes muddy. With the first concept one can foresee a gradual "civilizing" of the experimental area - an oiled apron here, grass or a more permanent plant-type cover there, and past roads to old experimental sites useful for current installations.

NOTE: In this discussion comparison information has been obtained by scaling recent DUSAF drawings and using various sources for cost information. It is presumed DUSAF would do more definitive layout work and prepare detailed cost estimates if any of these proposals are to be carried further.

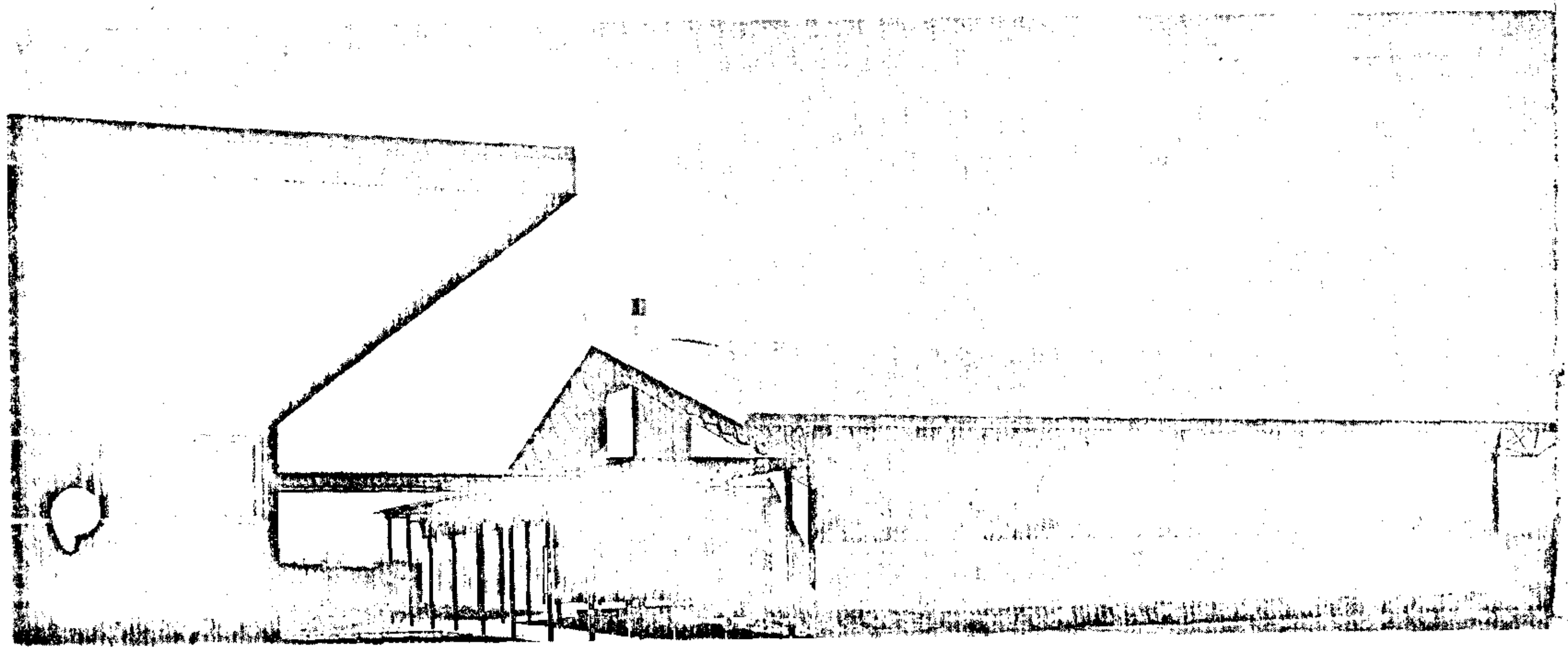
Jaycee Park Pavilion, Wayne, Michigan



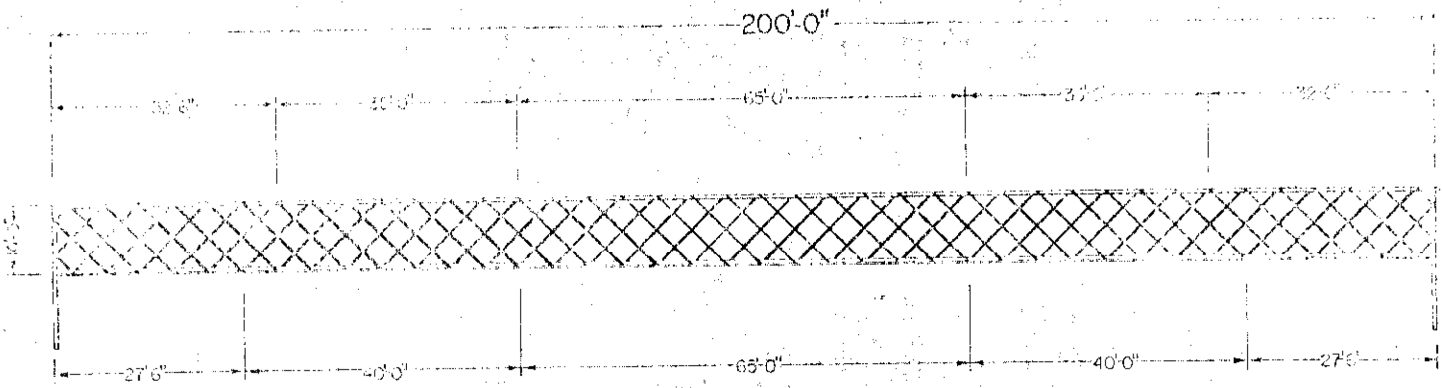


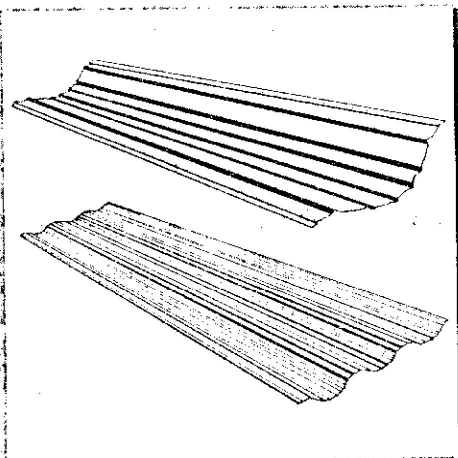
Unistrut of Canada Ltd., Chatham, Ontario, Canada

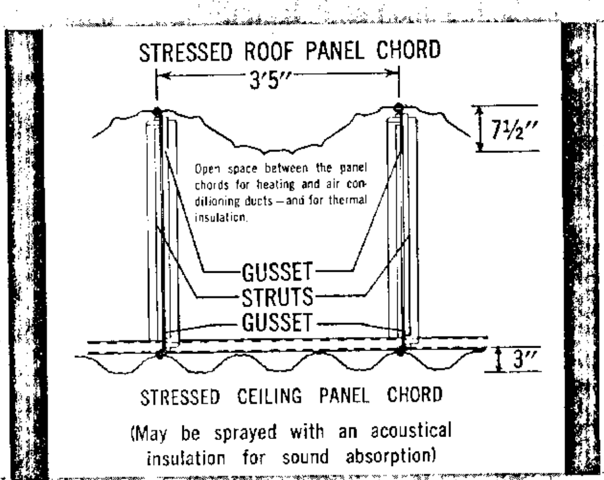
Sheldon School Multi-Use Building, Canton Township, Michigan

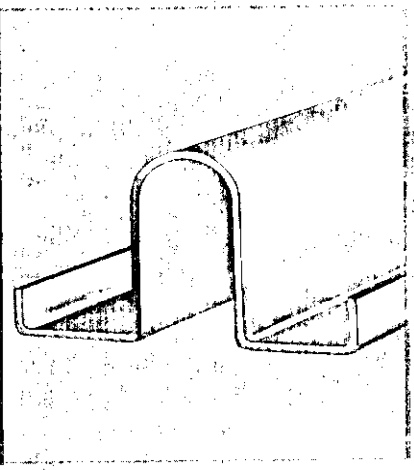


Typical DUBL-PANEL™ 200-Foot Span Roof-Ceiling Unit









Span: 200 feet
Depth of strut system: 10 feet (1 to 20 ratio, depth to span)

Panel-chords:

54'—20 gauge
70'—18 gauge
132'—13 gauge (41" oc)
80'—14 gauge
65'—12 gauge

Other materials: Struts, bolts, gussets, panel sealer

Finish: Galvanized or aluminized or combination (painting optional)

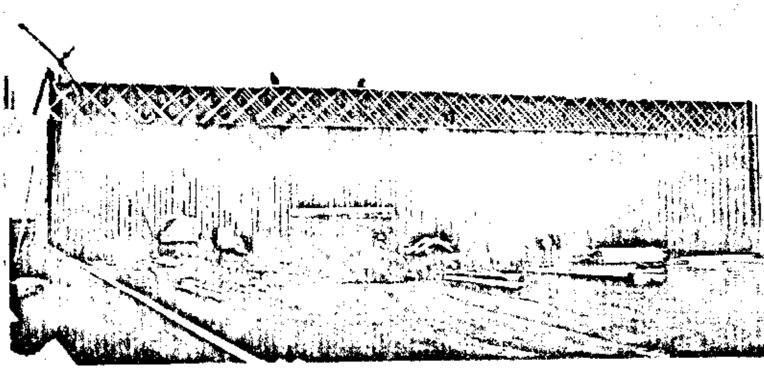
Dead Load: 10.52 psf

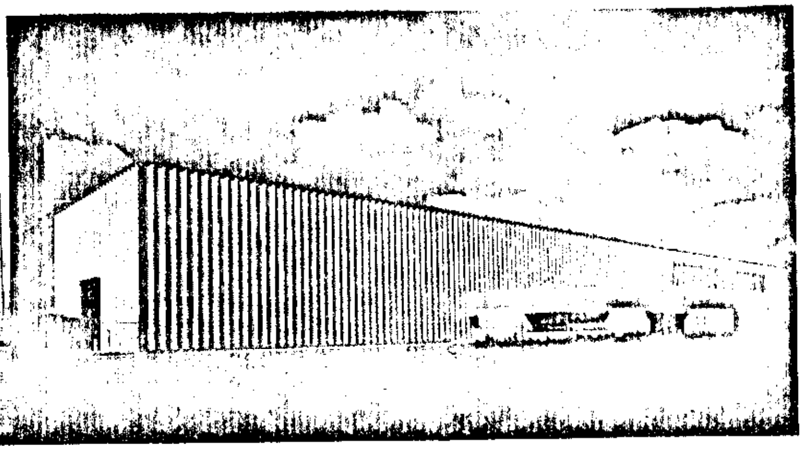
Live Load: 30.00 psf

Wind Load: 20.00 psf

Struts

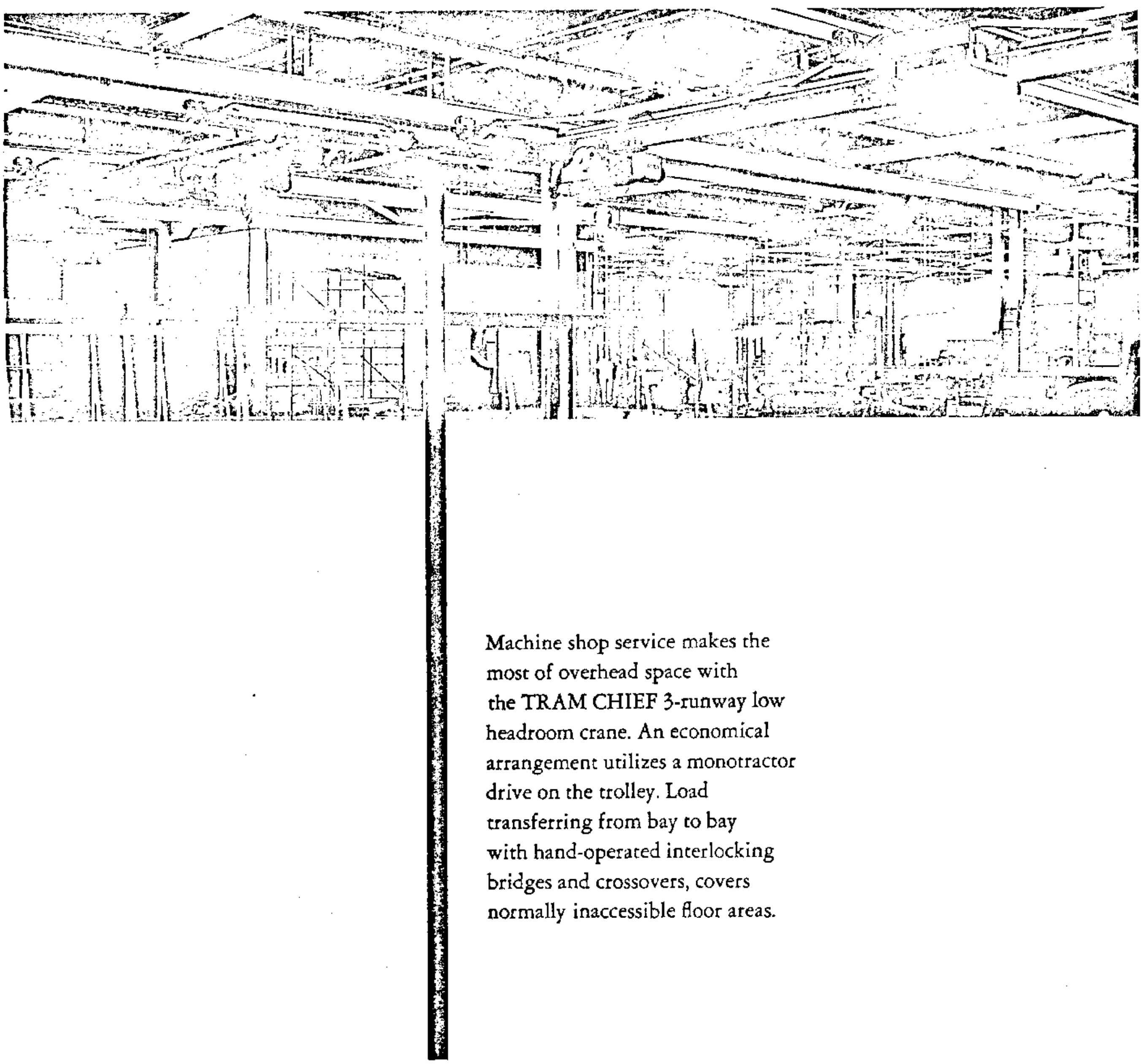
Struts vary from 13 to 20 gauge. Their "U"-shaped design has been tested for optimum performance according to span and load.





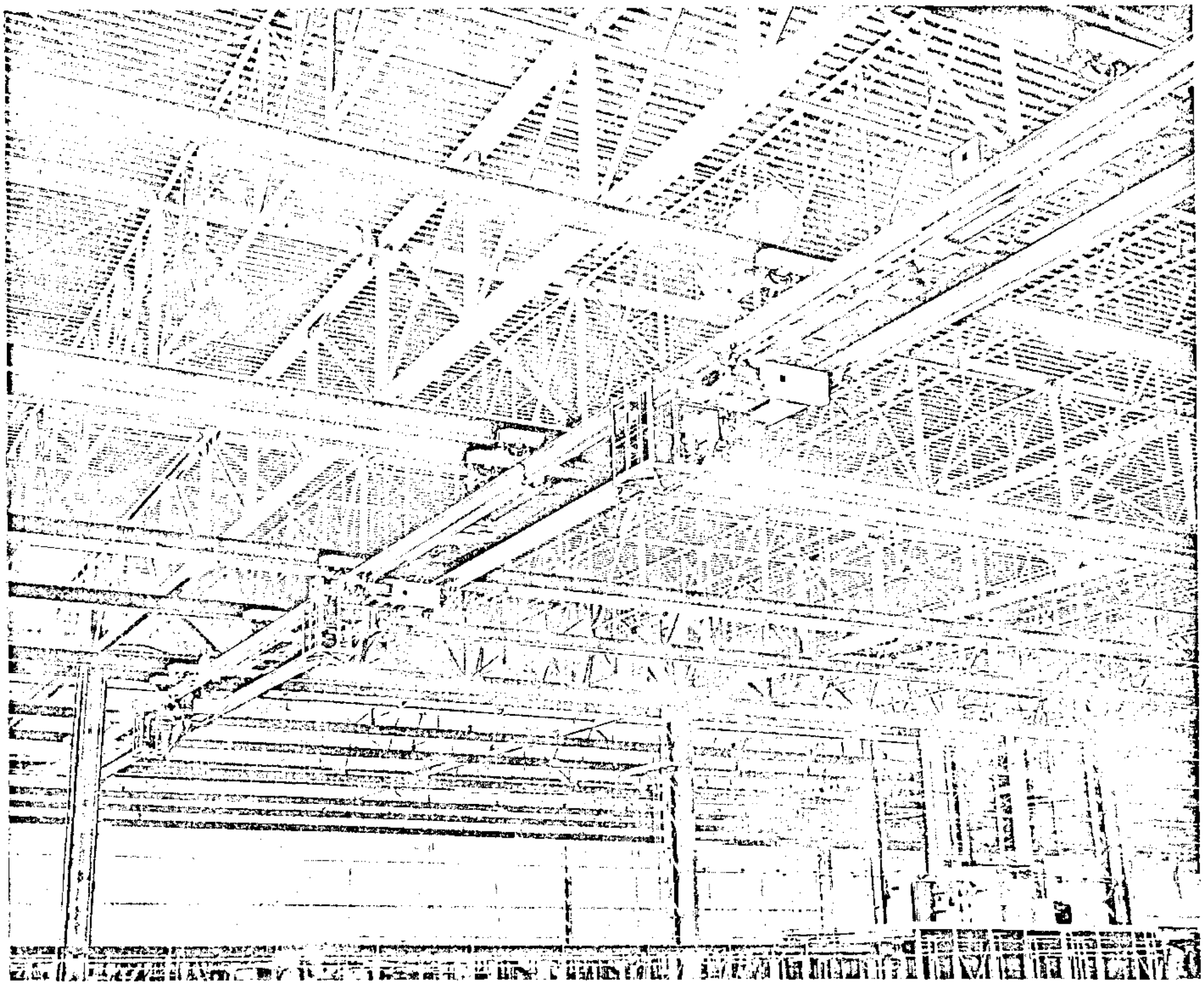
Buildings go up fast—using the Behlen panel building method. Panels assemble easily because each section is precision fabricated and punched for bolting to adjacent units. And a weather tight shell is formed with life-time sealer in every seam. The roof is completed in a one step operation. This quick enclosure allows interior finish to start sooner . . . permits earlier occupancy.

One hundred percent functional—the impressive new facilities of Intercontinental Engineering in Kansas City, Missouri meets their requirements for a high, wide, functional structure. Long, unbroken lines of fluted steel paneling form a striking backdrop for the low, modern office annex. And a bright alumanized steel exterior will remain maintenance-free for years.



Machine shop service makes the most of overhead space with the TRAM CHIEF 3-runway low headroom crane. An economical arrangement utilizes a monotractor drive on the trolley. Load transferring from bay to bay with hand-operated interlocking bridges and crossovers, covers normally inaccessible floor areas.

TRAM CHIEF CRANES SERVING THE INTER CONTINENTAL BALLISTICS MISSILE PROGRAM



Four 90 foot TRAM CHIEF cranes can be interlocked to form two 180 foot spans and with crossover connections 5¼ acres of this huge plant are effectively covered. Three cab operated double girder trolleys work in conjunction with all four bridges wherein any one crane will accommodate two trolleys supporting a combined load of 20 tons. The TRAM CHIEF trolleys are equipped with positive slow speed control of 2 feet per minute on the first step—and hook speed is maintained regardless of load for both raising and lowering. This precision hoisting feature allows complete control for spotting loads to within a few thousandths of an inch.

Another TRAM CHIEF standard—three ton capacity, three runway, 72'-0" total span single girder TRAM CHIEF crane. Two of these units are used on the same set of runways and cover a very large special steel warehouse. This TRAM CHIEF crane illustrates the ease and simplicity of construction for single girder long span use. Items to be noted are the TRAM GIRDER attachments to the reinforced welded building girders, the "let-in" construction of the end trucks and bridge girder for low headroom service, the compact cross-mounted low headroom hoist and trolley, the center-mounted bridge drive, and adjustable dual semi-pneumatic tire drives at each truck.