THE LIGHTING OF SHIELDS-WATKINS FIELD FOR NIGHT FOOTBALL

by

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Preface

Feeling that a new field has recently been opened to the engineer, and especially the lighting engineer, the author has attempted to devote some time and possible research towards making recommendations for the lighting of Shields-Watkins Field, at the University of Tennessee, for night football. The recommendations are general, yet detailed enough to warrant their perusal, if the field should be lighted within the near future. The plans are designed for present conditions, and some modifications would be imperative if the present status of the concrete stands should be changed materially. Strictly technical details have been omitted, since the scope of the thesis is not intended to cover such items.

The treatment of the subject is a purely local one, but the standard methods of performance have been followed. Since night football is a fairly recent development, the recommendations are largely personal in some places.

Past and Present Developments

Night football was originated by a few schools who found it difficult to draw attendance for games on Friday and Saturday afternoons. The list of lighted football fields has grown to include many major colleges and universities, along with a larger number of high schools. The increase in attendance at these night games at the larger schools has more than paid for the installation costs, but the increased patronage at the smaller colleges and high schools, where games must be scheduled in competition with other sports, has been phenominal. The increased attendance has been reported from many schools at 50 percent to 400 percent where night games have been played.

Only two years ago night football was very much a novelty, while at the present time it is becoming accepted practice. Colleges that have been struggling along, depending upon the football receipts to carry the entire athletic program, have at last climbed from a financial rut for the first time. The night games have developed a new following. Friday night has usually been accepted for night football games, and this allows many working people to attend.

Schools in the South having installed the night system include Georgia Tech, Maryville College, Soldier's Field at Birmingham, McCallie School and Knoxville High School.

Perhaps night football violates the time-honored traditions of the game, but next fall not less than 300 schools and colleges will be playing the game under lamp light.

Purposes for which a field can be used at night, other than for football, include pageants, boxing, field meets, wrestling, circuses and military drill.

Theory

A football field illuminated to an intensity of approximately 10 foot candles will give satisfactory operation. There will be few shadows at this intensity, which is quite desirable. Shadows are to be eliminated under all circumstances.

The height of the light source must be as high as it is economically possible. This tends to shorten all shadows. The players seldom have occasion to look directly at the lights, and the lights give little difficulty when placed high. The beam of the floodlight is directed nearly straight down, and spectators on the opposite side of the field are not bothered by the glare.

Tower installations are usually placed behind the stands, while the pole type of installation is placed between the stands and the edge of the football field. The floodlighting projectors on the towers, often being some distance from the field, should be the enclosed type. This type of projector is used to concentrate the beam of the lamp.

The height of the tower bears a definite relation to its distance from the edge of the field. See drawing No. 4 for details. The projector beam angle should be selected to just include the playing field. The projectors may be focused to provide the spill light necessary for punting and passing. The lights on each tower should be adjusted with all other towers turned off to provide accurate focusing. The projectors should be focused for minimum divergence with the doors opened. The doors should then be closed, and the beams focused to light the near side of the field with the upper edge of the beam sighted at the farther edge of the field.

Difficulties

The recommendations for towers are different for each side of the field. The upper edge of the West stadium is so far from the field that it would require a very high tower. This would require a large base, causing added expense for both the base and tower. While the construction is not symetrical, it does not impair the efficiency of the system.

The press box will have to be moved, but it can be rebuilt at reasonable cost. A larger press box is really needed.

The nature of the soil around the base of the towers is unknown, so the tower footings on the East side of the stadium have been estimated. Actual tower footings should be referred to the tower manufacturer.

The chief difficulties encountered at night football games are fog and cold weather. Precautions can be taken against cold weather by added clothing most of the time. The presence of fog is rare, and has really offered little trouble.

General Recommendations

Lighting

According to the present day standards, the total connected load required to adequately illuminate a football field is about 45 KW, but the tendency is towards higher intensities. Suppose the actual installation to be 48 KW. The average time required for the game and pre-game practice is approximately $2\frac{1}{2}$ hours. A major university usually plays 8 home games each season. On this assumed basis, the total energy required for a season would be approximately 960 KW hours.

Lamps and Lamp Voltage

The general practice of burning lamps 10% over voltage is economically sound and is usually recommended for football field lighting. When a Mazda lamp is operated at 10% over-voltage the light output is increased approximately 38% and the voltage only 16%, a noticeable gain in lumens generated per watt consumption. When operated at 10% over-voltage, the life of the lamp will be sufficient to insure satisfactory service for the entire season. It is seldom economical to burn lamps at 10% over-voltage, if the current rate is lower than 2 cents per KW hour, because the cost per lumen hour is about equal for both systems as far as actual operating costs are concerned. However, approximately 40% more 1000 watt floodlights are required to supply the same illumination with lamps operating at normal voltage, and the costs of towers, wiring, and labor would be materially increased. Since the university produces its own power for lighting, it is economically sound to burn lamps at 10% over-voltage.

Standard voltage lamps should be used since they are usually in stock. The voltage of the system should be 115 volts, and the rating of the lamps should be 105 volts and 1000 watts.

Floodlighting Projectors

The floodlights are the enclosed type, equipped with 1000 watt lamps, and

mounted on the towers as shown on Drawings No. 4, 1 and 2. The enclosed projector is more efficient, stands up well under service, and provides more illumination on the central portion of the field since the beam can be concentrated and focused.

Transformers and Wiring System

A distribution transformer has been located under the concrete stadium on each side of the field. When transformers are located at a central point, large size wire must be used to distant towers, or the voltage crop will be excessive. This causes a power loss, and a difference in voltage that is supplied to the various towers. The wiring system has been designed to prevent excessive voltage drop, and to obtain proper voltage at all lamp sockets. If it is desired, the wire size can be increased to provide for 1500 watt lamps during the future. Refer to drawings No. 1 and 2 for location of transformers.

Towers and Bases

The type, height, and cost of the towers has been recommended, but it is advisable to consult the tower manufacturer for tower construction details. The design depends largely upon the layout of the particular field. The design of the base depends upon the type of soil that is present. It is recommended that the towers be placed back of the East stadium, while the towers have been placed on the upper edge of the concrete stands on the West side. This is done because the distance from the field is so large that the proper height of the tower would necessitate an exceedingly large and expensive base, as well as increase the cost of the tower. The height of the towers on the East side should be 80 feet, and the light source on the West side should be 110 feet above the level of the playing field. The actual height of the tower alone should be 32 feet.

The bases should be made of concrete meeting standard specifications. The size of the base should be 7' x 7' x 12' for the East side of the field and 7' x 7' x 5' for the West side. The base on the West side should make a secure

bond with the existing concrete. However, actual details of construction and size should be left to the tower manufacturers. Refer to drawing No. 4 for details of bases.

Supply Line

The supply line should be brought in from Estabrook Road. Each side of the field may be operated entirely independent of the other side. The line for the West side should be brought from the present 2300 volt line, near the gymnasium on Estabrook Road, to the northwest corner of the West stadium. It can then be run along the back of the stadium to the distributing transformer beneath the middle tower and under the stadium. The supply line for the East side should be connected to the existing 2300 volt line just West of Estabrook Hall. The span can be run directly to the transformer beneath the stadium. See drawing No. 3 for details of supply line.

Switches

Occasionally at night all the lights may not be required. It is recommended that a Trumbull safety switch be located at the base of each tower to enable independent control from each tower.

Press Box

The center tower on the West side has been placed where the press box is now located. The press box, constructed of wood, should be moved due south until it does not interfere with the tower. A double-decked press box should be erected to provide for pressmen at the bigger games.

Specifications of Material

1. 24 G.E. Type L-31A Novalux floodlighting projectors, lightly stippled clear lenses, catalogue No. 1229485G-16.

   These projectors are to be used on East side of field.

2. 24 G.E. Type L-31A Novalux floodlighting projectors, with plain clear lenses, catalogue No. 1229485G-13.

   These projectors are to be used on West side of field. See print No. 6.

3. 48-1000 watt Mazda PS-52 clear lamps, rated at 105 volts. (10% less than circuit voltage.)

4. 3 Steel towers - 80 feet high; to be used on East side of stadium. See drawing No. 4 for details.

5. 3 Steel towers - 32 feet high; to be used on West side of stadium. See drawings No. 1 and 4 for details.

6. 2 - 37.5 Kv-a G. E. Type H. distribution transformers, 2300/4000 Y to 115/230 volts. Catalogue No. 198389.

7. 6 Trumbull type A. fusible safety switches, 250 volts, 3 pole, 60 amperes, catalogue No. 72322.

8. 6 G.E. Safety panelboards, for 8 circuits, 3 wire mains, complete with weather proof inclosing box. G. E. Catalogue No. 2364.

9. 3 Concrete tower bases, 7' x 7' x 12'.

   Mix of 1-2-4.

   See print No. 4 for details.

10. 3 Concrete tower bases, 7' x 7' x 5'.

    Mix of 1-2-4.

    See drawing No. 4 for details of size and position.

11. 800 ft. (approx.) of 3 conductor No. 6 A.W.G. Parkway cable, 600 volt insulation, with CA, CLA, or CLAI finish.

12. 2200 ft. (approx.) No. 6 A.W.G. Standard N. E. code wire.

13. 600 ft. (approx) 1¼" black conduit.

14. 100 ft. (approx.) 1¼" black conduit.

15. 12 - 1¼" black standard 90° elbows.
2300 volt supply line.

16. 6 - 35 foot, 7" top creosoted pine poles.

17. 6 anchors.

18. 5 Single three-pin cross arms.

19. 2 double three-pin cross arms.

20. 30 insulators.

21. 2300 feet (approx.) No. 4 weatherproof wire.

22. 3000 ft. of Lumber (12' x 6" x 1")

23. 1000 ft. of Lumber (12' x 4" x 2")

24. 40 lbs. of No. 8 nails.

25. 20 lbs.of No. 20 nails.

26. 20 - 3 wire brackets.

Calculations of Cost - Materials

1 & 2. 48 G.E. Floodlighting Projectors.
48 x $63.00 = $ 3,024.00

3. 48-1000 watt P.S.-52 lamps
48 x 3.20 = 153.60

4. 3 Steel towers - East Side
3 x 450.00 = 1,350.00

5. 3 Steel towers - West Side
3 x 200.00 = 600.00

6. 2 - 37.5 Kv-a G. E. Type 'H' Transformers
2 x 260.00 = 520.00

7. 6 Trumbull Type 'A' safety switches
6 x 10.00 = 60.00

8. 6 G. E. Safety Panelboards
6 x 5.85 = 35.10

9. 3 Concrete tower bases.-East Side, size 7' x 7' x 12'

$\frac{7x7x12}{27}$ = 21.8 cu. yds. of concrete per base
9.00 x 22 x 3 = 594.00

10. 3 Concrete tower bases.-West side,7' x 7' x 5'

$\frac{7x7x5}{27} + \frac{7x7x4}{2x27}$ = 12.75 cu.yds.concrete per base
10.00 x 13 x 3 = 390.00

11. 800 Ft. 3 conductor,No. 6 A.W.G. Parkway cable
$160.00 per 1000 ft.
$160.00 \times \frac{800}{1000} =$ 128.00

12. 2200 ft. No. 6 A.W.G. Standard N.E. code wire
$26.00 per 1000 ft.
2.2 x 26.00 = 57.20

13. 600 ft. of $1\frac{1}{4}$" black conduit
$13.50 per 1000 ft.
$13.50 \times \frac{600}{1000} =$ 8.10

14. 100 ft. of $1\frac{1}{2}$" black conduit
$16.00 per 1000 ft.
$16.00 \times \frac{100}{1000} =$ 1.60

15. 12 - $1\frac{1}{2}$" black standard 90° elbows
12 x 0.27 = 3.24

16. 6 - 35 ft. pine poles
6 x 9.75 = 58.50

17. 6 Anchors
6 x 2.75 = 16.50

18. 5 Single 3-pin cross arms
5 x 1.60 = 8.00

19. 2 Double 3-pin cross arms
2 x 3.50 = 7.00

20. 30 Insulators
30 x 0.15 = 4.50

21. 2300 Ft. No. 4 Weatherproof Wire
164# per 1000 ft.
$0.20 per pound
164 x 2.3 x 0.20= 75.50

22. 3000 Ft. of Lumber (12' x 6" x 1")
3 x 34.00 = 102.00

23. 1000 Ft. Lumber (12' x 4" x 2")
1 x 40.00 = 40.00

24. 40# No. 8 nails
40 x 0.08 = 3.20

25. 20# No. 20 nails
20 x 0.10 = 2.00

26. 20 - 3 wire brackets
20 x 0.60 = 12.00

Cost of Installation

1.	Erection of Towers		
		6 x $50.00 =	300.00
2.	Bases for towers		
		6 x 100.00 =	600.00
3.	Erection of 2300 volt line--		
	Setting poles		
	6 x 5.75 = $34.50		
	Setting anchors		
	6 x 2.00 = 12.00		
	Stringing wire		
	2300 x0.05 = 11.50		
	Engineering - 10.00		
	Total $ 68.50		68.50
4.	Drayage and hauling of material		75.00
5.	Removing and rebuilding double-deck press box		175.00
6.	Cost of focusing lights, locating transformers, bases for transformers, wiring towers and projectors, and general labor		330.00
7.	Profit to contractor		400.00
		Total	$ 9,205.54

Conclusion

While the scope of the recommendations are local, the subject is one that might well be standardized. It is hoped that the University of Tennessee will remain a modernized institution, and that the school may see fit to install night football if the occasion arises.

Located as it is, the institution could defray a considerable amount of the cost by collecting a nominal fee from the city schools using the field.

The recommendations might have included an underground wiring system, but the expense of such an installation is rather high. Since the University is probably not in a position or mood to install such a system, the overhead wiring system has been recommended. It is fully as effective, and somewhat less expensive.

Bibliography

Westinghouse Lighting Service News - No. 39.

Principles of Illumination, N. E. L. A.

Franklin Specifications for Good Lighting.

General Electric Co. Catalogue.

Newspaper and Magazine Articles.

Appendix

1. Drake played her first night football game last season against Simpson. In the afternoon game of 1929, 2,800 people were present. The nocturnal affair drew 8,200 spectators, outdrawing the Nebraska-Iowa State game at Ames, 35 miles away, that afternoon, by 2,500.
2. In the Drake-Grinnell night game, the largest crowd in the 32 years of playing was present. There were 12,000 people.
3. Marquette, of Milwaukee, with one less game than usual on the schedule, drew 15,000 more spectators than in any previous season.
4. Syracuse, in her annual game with Hobart, which usually drew 4,000 people, played to 22,000 people at night last fall.
5. The Creighton-St Mary (Kan.) game has usually drawn around 4,000 people. It drew 9,000 last October in Omaha at night.
6. Washington University met Drake in the first night football game ever played in St. Louis and drew 16,000 people, more than 3 times the number of spectators that ever saw a Drake-Washington U. fracus.
7. The Haskell Indians have usually drawn 6,000 spectators when playing Creighton at Omaha by daylight. The largest crowd, 16,000, to ever attend such a game, saw the two schools play last season at night.
8. The Syracuse-John Hopkins night game drew 10,000 to 12,000 more people than would have attended a daylight game, and at $1.00 each would have paid for the total lighting system.
9. The paid attendance at Tacoma's first night game paid for a very fine lighting system.
10. The University of North Dakota reported a 50 percent increase in attendance for the first game of 1929 at night over the corresponding game of 1928.
11. Ten night games were played in Pasadena Rose Bowl in 1929 with paid attendance ranging from 18,000 to 32,000 people per game. Similar day games had drawn less than 4,000 people.

12. Georgia Tech's lighting system was turned on too late last season for a regular game, but a freshman-scrub game that had ordinarily drawn 1,500 people drew 8,000 in spite of rain.

13. Legion Field, Birmingham, successfully demonstrated the possibilities of night football with a $15,000 installation.

14. The field at Trenton, Indiana, was paid for out of the first year's receipts, and the school still had a greater net profit than for the previous year.

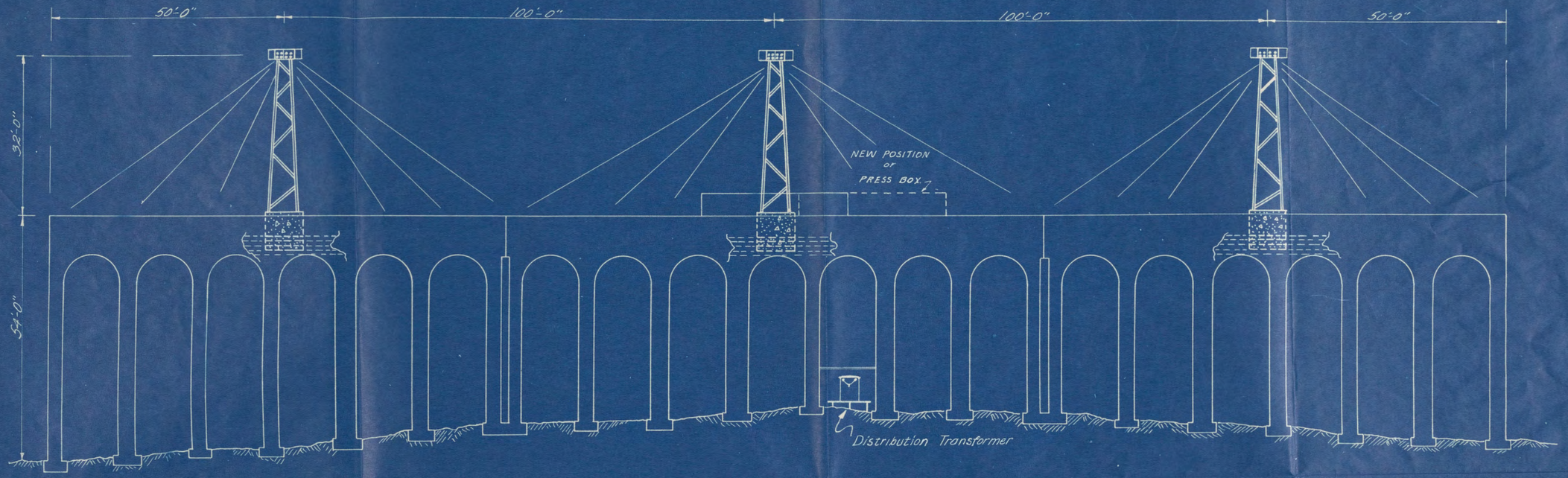
APPROVAL

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is to be understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it is submitted.

Name J. G. Tarboux

Title Prof Elec. Eng.

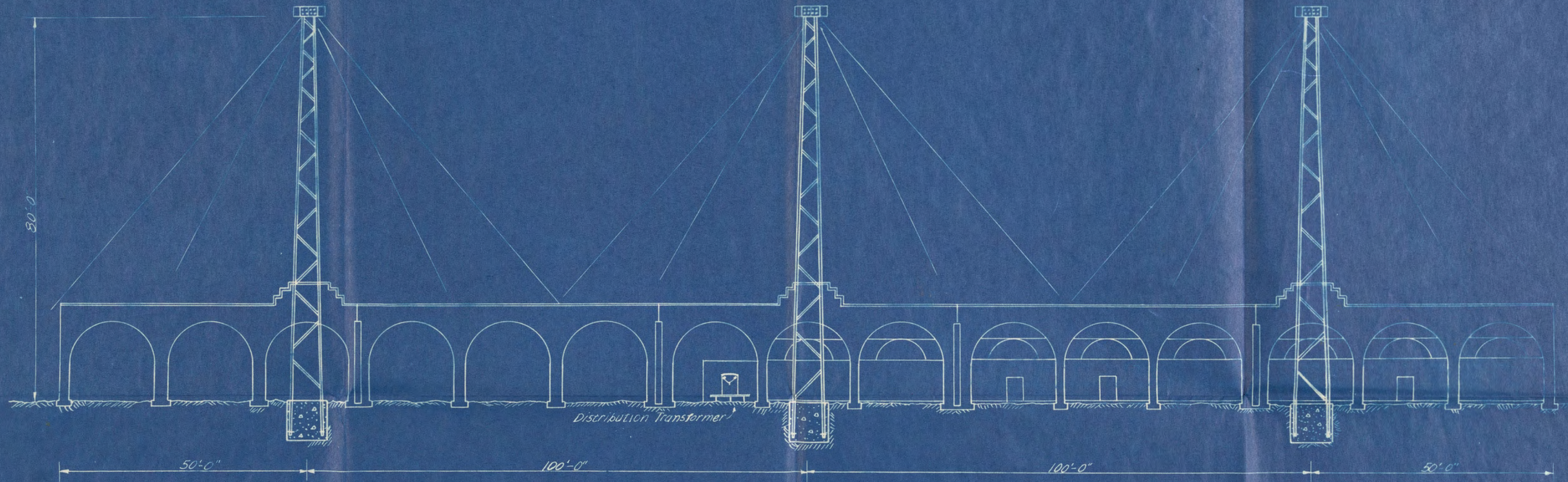
DRAWINGS



REAR ELEVATION
WEST STADIUM
SCALE - 1"=16 FT.

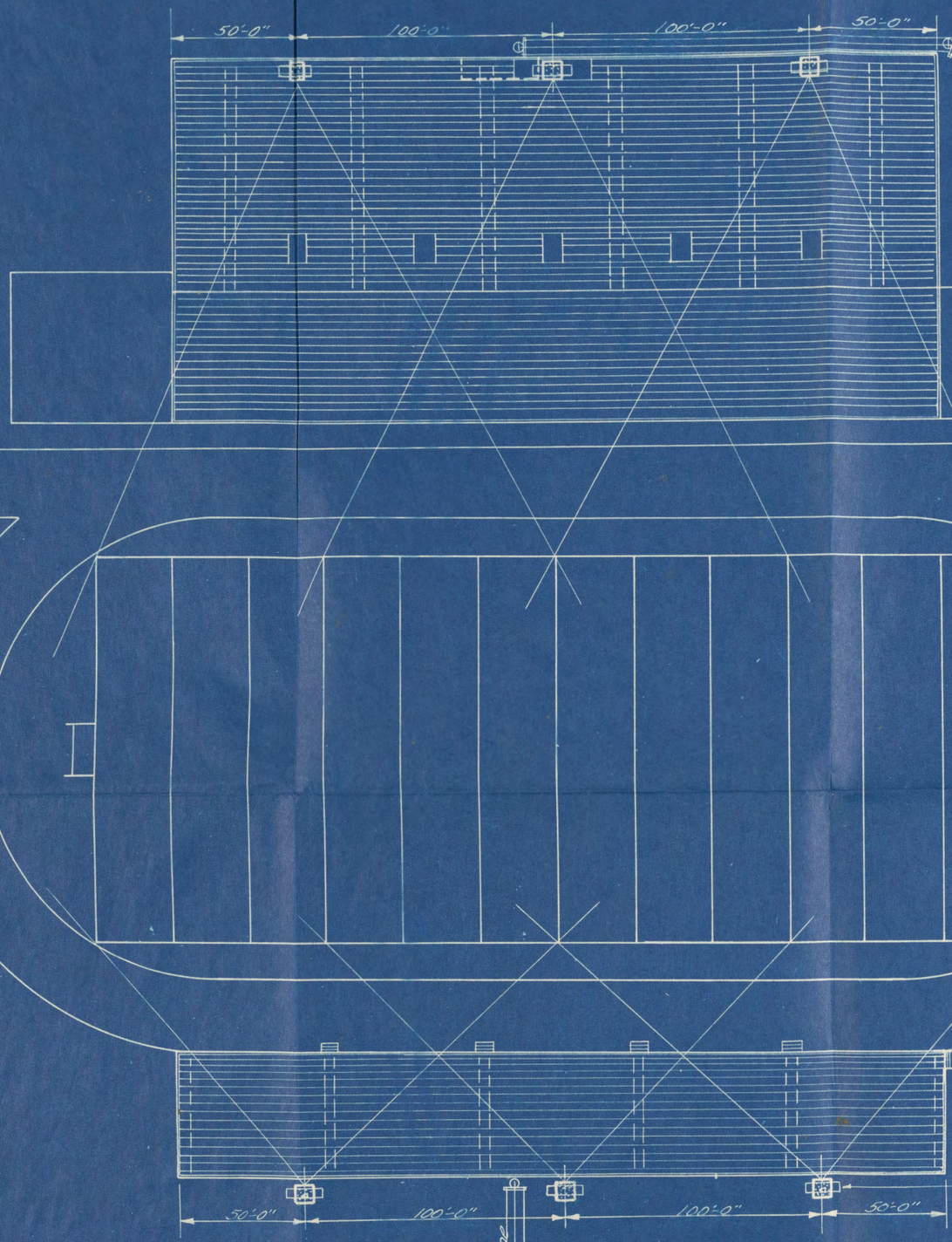
LIGHTING RECOMMENDATIONS
SHIELDS-WATKINS STADIUM
UNIVERSITY OF TENNESSEE
KNOXVILLE, TENN.

DRAWN BY RODGER DODSON
DRAWING NO. 1



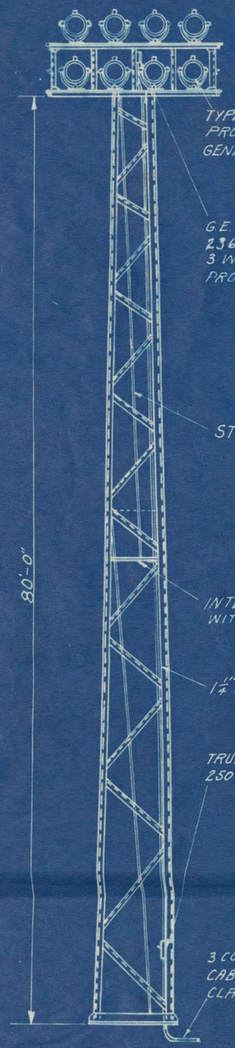
REAR ELEVATION
EAST STADIUM
SCALE - 1"=16 FT.

DRAWING NO 2.



PLAN VIEW
OF
SHIELDS-WATKINS FIELD
SHOWING
LOCATION OF SUPPLY LINES & TOWERS
SCALE - 1" = 40'

DRAWING NO. 3.



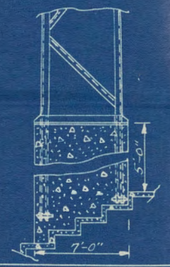
SCALE - 1" = 8 FT.



TOWER FOOTING EAST SIDE

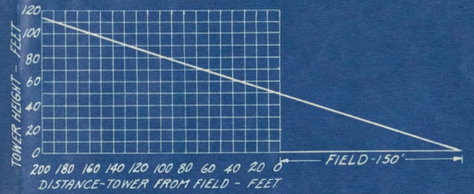


TOWER FOOTING WEST SIDE

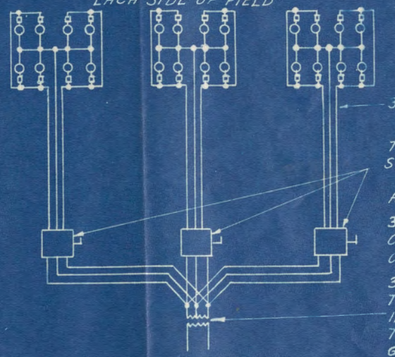


TESTS SHOULD BE MADE FOR LOCAL SOIL CONDITIONS. SPECIFICATIONS FOR THESE FOOTINGS SHOULD BE REFERRED TO TOWER MANUFACTURER.

MINIMUM HEIGHT OF TOWERS



WIRING DIAGRAM FOR EACH SIDE OF FIELD



3-#6 STANDARD N.E. CODE WIRES - 1¼" CONDUIT.

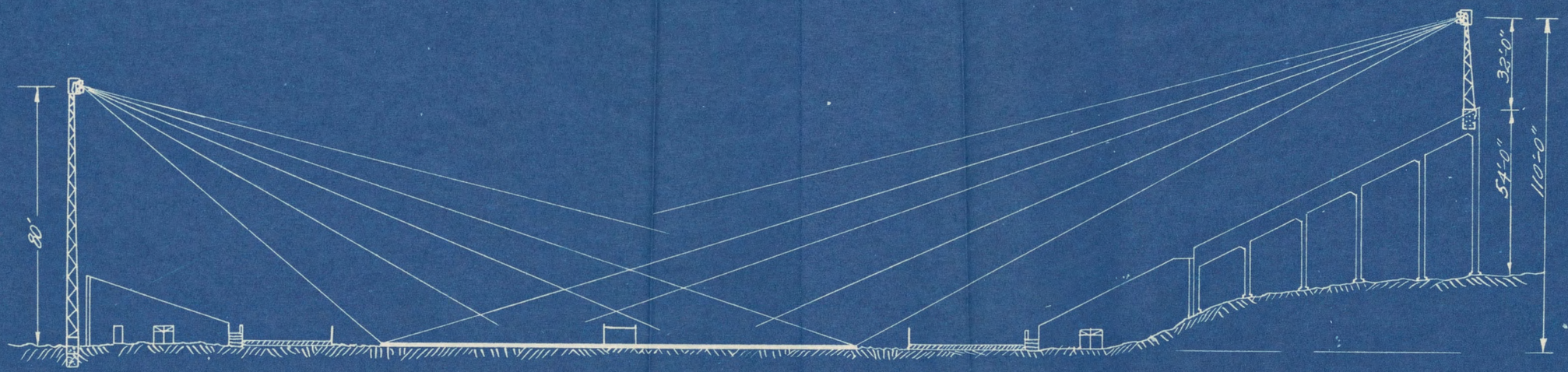
TRUMBULL TYPE 'A' FUSIBLE SAFETY SWITCHES - 250 V. 3 POLE, 60 AMP. SWITCHES LOCATED AT BASE OF EACH TOWER.

3 CONDUCTOR #6 A.W.G. PARKWAY CABLE 600 VOLT INSULATION CA, CLA, OR CLA1 FINISH.

37.5 KVA G.E. TYPE H DISTRIBUTION TRANSFORMER 2300/4000 Y TO 115/230. TRANSFORMER IS LOCATED UNDER GRANDSTAND NEAR CENTER TOWER.

DETAILS OF TOWERS, TOWER BASES AND WIRING DIAGRAM FOR SHIELDS-WATKINS FIELD UNIVERSITY OF TENN. KNOXVILLE TENN.

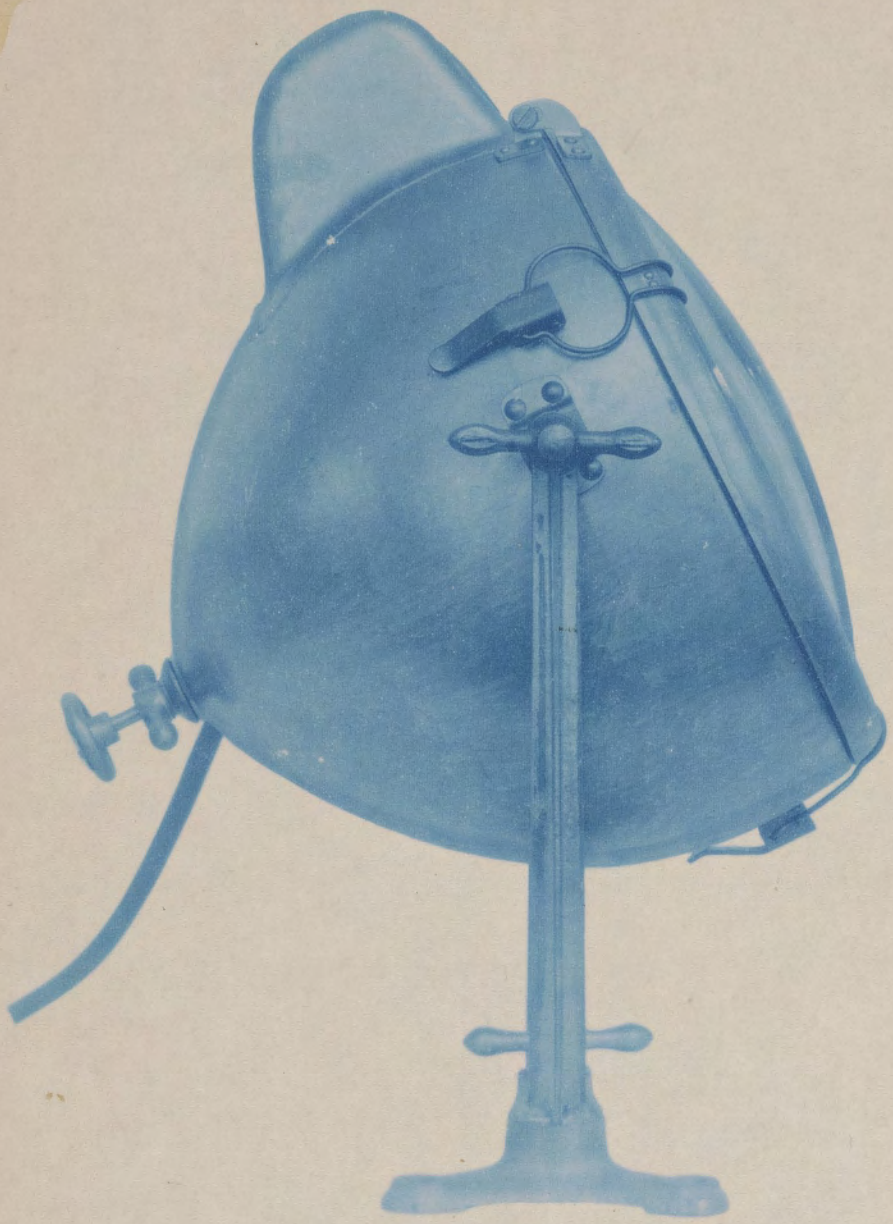
DRAWING NO. 4.



NORTH END ELEVATION

SCALE - 1" = 40 FT.

DRAWING NO. 5



PRINT NO. 6

716583 G-E FORM L-31A FLOODLIGHTING PROJECTOR WITH NEW-TYPE REFLECTOR. APPROX. 1/4 SIZE.

E351.4 2-6-30