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Decision No. 34444

Decision No._____

BEFORE THE RAILROAD COMMISSION OF THE STATE OF CALIFORNIA

In the matter of the application of The City of Los Angeles, a municipal corporation, and the Board of Public Service Commissioners of the City of Los Angeles, that the Railroad Commission determine the terms, conditions and manner of crossing the high voltage power line of the Pacific Light & Power Corporation, by the proposed high voltage power lines of the City of Los Angeles.	Application No. 2277

W. B. Mathews and W. B. Himrod and Lewis Whithead for City of Los Angeles.
Gibson, Dunn & Crutcher and S. M. Haskins for Pacific Light & Power Corporation.
H. H. Trowbridge, Harry J. Bauer and E. W. Cunningham for Southern California Edison Company.

EDGERTON, Commissioner.

O P I N I O N

This is an application of the City of Los Angeles and the Board of Public Service Commissioners of the City of Los Angeles requesting this Commission to determine and fix the character of construction and the location of each line at a crossing of the proposed power lines of the City of Los Angeles with the "Big Creek" lines of the Pacific Light and Power Corporation.

Applicants have under construction a steel tower transmission line from their hydro-electric generating plant located in San Francisquito Canon (Section No. 27, Township 6 North, Range 15 West) to the City of Los Angeles. This line will have a total length of approximately 47 miles. The

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proposed route, for which rights of way have been secured, traverses the mountainous country north of San Fernando Valley in a direction almost due north and south. It enters the Valley for a few miles north of San Fernando, at which point the proposed crossing is located. The Pacific Light and Power lines also enter the Valley in this vicinity but occupy the ridges along its eastern slope, which they parallel into the main substation located at Eagle Rock.

The City contemplates a comprehensive development of hydro-electric power along the aqueduct and in the watershed of the Owens River. The ultimate plan provides for seven plants of a total capacity of 138,000 kilowatts, and four 110,000 volt circuits carried on two tower lines. The length of transmission from these plants to Los Angeles will vary from 24 to 270 miles. It is expected that the load supplied will be primarily lighting.

The initial development which is rapidly approaching completion comprises a partial installation in San Francisquito Plant No. 1, one tower line supporting two 110,000 volt circuits, and a receiving substation in Los Angeles. The capacity of San Francisquito No. 1, when completely installed, will be 55,000 kilowatts. Although but one line is to be constructed at present the right of way has been obtained for both lines, which will have a lateral separation of 100 feet. It is desired by applicants that provision be made for a crossing of both lines, and all suggested plans contemplate a crossing with two of the City's lines.

The transmission line as designed consists of two circuits of three 300,000 circular mil stranded copper cables, supported, three on each side, in vertical planes, by steel towers. The height of the standard tower is 76 feet overall,

50 feet to the lowest crossarm, the vertical separation of conductors being 10 feet and the horizontal 16 feet. The towers will normally be spaced 650 feet apart, except in crossing ravines where longer spans can be employed to advantage. The second line will be a duplicate of the first.

The Big Creek development of the Pacific Light and Power Corporation, as at present installed, is as follows: Two power plants, which have a capacity of 32,000 kilowatts each, located on Big Creek in the mountains east of Fresno, and two steel tower lines 240 miles long transmitting energy from the power plants to a substation in Eagle Rock where the voltage is reduced for secondary transmission and local distribution. Each line consists of one 3 phase circuit of aluminum, steel core cables of 683,500 circular mils cross section, carried in a horizontal plane. The normal operating line voltage is 150,000.

The lines occupy a private right of way 150 feet wide, normal separation being 82 feet and normal longitudinal spacing being 660 feet. In the mountainous country, however, longer spans are used, the maximum being 2,871 feet. The height of standard towers is 47 feet overall.

The topography in the vicinity of the proposed crossing is rugged. A deep ravine known as Grapevine Canon lies in a general northeast southwest direction between two ridges which project southwestward into the valley from the main range of hills lying north and south. As originally located, these lines would cross near the easterly side of Grapevine Canon at an angle of approximately 30 degrees, the City's lines paralleling the bed of the ravine and those of the Power Company crossing it diagonally from northwest to southeast. The spur range on the southeast side of this canon is known as Mustard Ridge. It

extends southwestward several hundred yards from the main range and is quite steep, and narrow at the summit, so that it is necessary to excavate in order to provide proper footings for towers. Two towers of the Big Creek line are located on the crest of this ridge near the eastern extremity. The proposed right of way of the City's line also contemplates two towers on this same ridge about 300 feet further west. A steep promontory extends into the ravine near the center of the crossing span of the Big Creek line, thus reducing the side clearance of the east line considerably at this point. The land in the vicinity of the proposed crossing is controlled by the Standard Oil Company. It is largely a decomposed oil shale and affords a rather insecure foundation on steep slopes.

For several months prior to the filing of this application, informal negotiations were conducted by engineers representing the City, the Power Company and the Commission, in an endeavor to devise a crossing which would be mutually satisfactory. During this period several alternative types of construction were proposed and investigated. The following is a brief description of these, given in the order in which they were advanced:

1. Simple overhead crossing, City's lines above Power Company's lines. Routing of lines - Company's lines same as at present constructed, City's lines in accordance with original right of way.

2. Simple overhead crossing, as in No. 1, except that the crossings are located in adjoining spans. Both City lines to cross Power Company's east line in Grapevine Canon and to cross Power Company's west line in the span immediately south of Mustard Ridge. This involves the re-location of the Power Company's west line; about 8,800 feet of it being shifted laterally westward a distance of some 600 feet. It introduces about 13 degrees of additional angularity in this line. Cost, estimated by City's engineers, $2,500.

3. Power Company's lines crossing over City's lines, the latter to occupy a steel frame skeleton structure supporting and protecting them. Power Company's lines to remain in present position. Structure situated on any one of several possible locations. Structure designed to effectually prevent possibility of contact upon failure of upper line and to permit working on either line without interfering with operation of the other. Considerable additional angularity would be introduced in the City's lines by this scheme. Approximate dimensions of structure, 150' x 52' x 30'. Cost of structure, $10,000 (Estimated by Power Company's engineers.)

4. Crossing to be made in a steel structure located on Mustard Ridge midway between the present location of the Power Company's lines and the proposed original location of the City's lines. Structure to be jointly occupied by lines of both parties and complete crossing to be made inside of structure. Clearance to be sufficient to permit working on either line while other is energized. Approximate dimensions of structure, 150' x 57' x 40'. Approximate cost, $6,000. (Estimated by Commission's engineers.)

5. a-Crossing of Power Company's lines over City's lines, each line supported by separate tower structures, located on Mustard Ridge. Power Company's lines to be shifted a short distance west and raised so as to permit City's line to cross underneath. Tower of City's east line located between Power Company's towers. Towers of corresponding lines of each concern placed as close together as practically possible to minimize distance to point of crossing from support. Slight additional angularity introduced into each line.

b- Same as 5 (a), except that the four lines occupy two joint structures on Mustard Ridge each structure supporting one City and one Power Company line.

c- Power Company's lines cross over City's lines. Tower locations same as in No. 1. Power Company's lines raised sufficiently to permit City's lines crossing underneath.

The above schemes were proposed before the filing of this application. Subsequent thereto, Mr. Barre, engineer for the Power Company, suggested another proposition, which we shall designate as No. 6, as follows:

6. Re-routing of both of the City's lines so as to permit Power Company's lines, occupying their present position, to cross over the City's lines in separate spans. This plan is identical in principle with No. 2 above, except that the positions of the two lines relative to each other, are reversed. This scheme would increase the angularity of the City's east line about 100 degrees, and that of the west line about 70 degrees. Both of the City's lines to be diverted toward the west at points several spans north of Mustard Ridge, and to cross under the Power Company's lines, thence southward paralleling the Power Company's lines to towers on Mustard Ridge near the original location.

Of the above propositions the first two were proposed by the City's engineer in the order named, the third and sixth, by the Power Company's engineer, and the fourth and fifth by the Commission's engineers. From an examination of the above, it will be noticed that these plans provide protection increasing in the following order:

No. 1 & No. 5 c.)	No protection against complete shut-down in case of failure of any conductor of the upper lines.
No. 5 a. & b.)	Somewhat greater protection but still possibility of complete shut-down.
No. 2 & No. 6.)	Elimination of the hazard of complete interruption of service attending the foregoing schemes unless the upper lines should fail simultaneously in the two crossing spans, also permits working on either upper line and the installation of the crossing without interruption of service.
No. 3 & No. 4)	These provide practically perfect protection.

At the time of the hearing of this application, the problem had resolved itself to a consideration of Propositions No. 2 and No. 6, the others having been eliminated for various

reasons. No. 1 and No. 5-c were discarded as affording insufficient protection, No. 5. a and b, upon investigation were found impracticable on account of the proximity of the Power Company's east line to the hillside and the necessary excessive height of towers for both Power Company's lines. No. 3 and No. 4 were abandoned because it was concluded that the additional protection obtainable would not warrant the large expenditure required.

Hearings were held on this application in Los Angeles on May 24th and 25th, 1916. Mr. E. F. Scattergood, electrical engineer for applicants, in his testimony advocated the adoption of Scheme No. 2. He stated that the configuration of the ground at the point of crossing is such as to place the City's lines naturally in the upper position; that the City originally intended to construct a simple crossing over the Power Company's lines, as described in Scheme No. 1 above, but this was objected to by the Company's engineers and Scheme No. 2 was evolved to meet this objection. While admitting that the upper position is inherently more desirable from the standpoint of operating hazard, he contended that the possibility of failure of any of the conductors is extremely slight with construction such as is to be employed in the City's lines. As illustrating this point he cited the experience of the Pacific Light and Power Corporation in operating the Big Creek lines, a single failure having been reported during more than two years operation. He testified that his estimate of the cost of Scheme No. 2 was $2,500 - $3,000, the plan being to construct the relocated line of new materials, thus permitting both lines to remain in service except while making transfer connections.

Prof. W. F. Durand, who has been associated with two

other engineers as a consulting board in the design of the City's power system was called by the city as a witness. In general his testimony corroborated that of Mr. Scattergood. He stated that he had endeavored to treat this matter as an engineering problem, independent of the contentions of the two parties to the controversy, and, after giving consideration to all the physical conditions, concluded that Scheme No. 2 would realize the condition of minimizing hazard of interruption and provide the best solution to the problem from the standpoint of all parties concerned. He contrasted Scheme No. 2 with Scheme No. 6, stating that the former would provide substantially as good a position for the Power Company's west line as that now occupied; that although the total angularity is increased some 13 degrees, it is distributed over several angles while the maximum angle is decreased 9 degrees. In regard to Scheme No. 6, he testified as follows:

> "The only other alternative which seems possible would involve a separation of the lines of the aqueduct power; but, in my opinion, the physical characreristics of such construction, the topography and the other conditions which are presented would be distinctly less favorable for such a line than is the proposed construction for the lines of the Pacific Light & Power Corporation. I should be, therefore, led to favor for this problem as a whole and considered as a piece of engineering construction, the general arrangement proposed on drawing O-188, City's Exhibit A."

Regarding the danger of interruption of service on both lower lines under Scheme No. 2, he stated:

> "Under the proposed plan there would be the elimination of any such possibility; at least, it is removed out of the bounds of any reasonable probability."

The Power Company called as chief witness Mr. H. A. Barre, its electrical engineer. His testimony was to the effect that the hazard would be material under Scheme No. 2 and this he attributed to the following:

> "To my mind, that hazard occurs more particularly from the insulator failure and the human element than it would from any possibility of strength of towers. I think that towers can be constructed strongly enough to hold the wires. I think foundations can be secured to develop the strength of the towers."

This witness made an extemporaneous estimate of the cost of Scheme No. 2 at $4,000 - $5,000.

No estimates were submitted of the cost of Scheme No. 6. Mr. Barre stated, however, that in addition to rerouting the City's lines it would necessitate raising two of the Power Company's towers by substituting for them anchor towers and heavier foundations.

The question of priority of occupation was not made an issue by either of the parties.

After analyzing the evidence submitted herein, both as contained in the testimony of the several witnesses, and the other information pertaining to the physical conditions involved in this crossing, it appears that the construction as embodied in Scheme No. 2 is the most desirable, viewed from the standpoint of both parties and the public. In reaching this conclusion I have given consideration to several factors, among which are: Minimizing the hazard of complete interruption to service on either power system; the design of a crossing requiring an expenditure commensurate with the value of the safety obtainable, as measured by the magnitude of the load and importance of the service supplied by each line; the existence or non-existence, in each case, of a reserve source of power; the topographical conditions

in the vicinity of the crossing as affecting the location of each line; the loss occasioned by a complete discontinuance of service over these lines, due, either to failure of the upper line, construction of the crossing, or repair work on the upper line; and the degree of hazard obtaining with a crossing of these lines, considering the character of construction employed and the adequacy of mechanical and electrical safety factors.

I am aware that, in crossings of other transmission lines, where the conditions of load and service are comparable, no special precautions have been observed other than the provision of adequate clearance and proper safety factors. In this case, however, aside from the importance of either line, the difficulty of making repairs, and the consequent length of interruption, should failure occur, appear to warrant the additional measures and attendant expenditure provided by Scheme No. 2.

The Power Company made the point that the more important line should have the less hazardous position regardless of which line is first in place. As a general proposition I am inclined to agree with this view, however, in this case it appears, considering the future development contemplated by applicants, that there will be little to choose between the two transmission systems in the matter of importance.

Regarding the distribution of the cost of Scheme No. 2, it was agreed by both pa rties that, in the event this plan were adopted, the work on the Power Company's lines should be done by it and the cost thereof should be borne by the City.

In an overhead crossing of this type it is most essential that the clearance and safety factors be ample. Accordingly I recommend that the City's lines at this crossing conform to the specifications set out in the form of order herewith submitted, which have been tentatively adopted by this Commission as supplementing its General Order No. 26, the la tter containing no provision applicable to tower line construction. These regulations provide for a safety factor of not less than 3, against mechanical failure based on the ultimate strength of material under the assumed worst conditions of loading. The provisions regarding temperatures, wind velocities and ice loads are so worded as to permit the application of local climatological conditions. The proposed design of the City's lines and structures involved in this crossing have been checked by engineers of this Commission and the Power Company, both as regards clearance and safety factors under the conditions set forth in these specifications and found to comply therewith, with the exception of but two members. In regard to the two members above mentioned - the conductor clamp and strain insulator equalizing yoke, it was stipulated by the City's engineers that suitable special devices would be designed for use on this crossing, to have a safety factor of not less than 3.

O R D E R

Application having been made by the City of Los Angeles and the Board of Public Service Commissioners of the City of Los Angeles, for an order determining and fixing the character of construction and location of electric power lines of said city to be constructed across the electric power lines

of the Pacific Light & Power Corporation, and a hearing having been had,

IT IS HEREBY ORDERED by the Railroad Commission of the State of California that the electric power lines of the City of Los Angeles may be constructed across the electric power lines of the Pacific Light and Power Corporation in Grapevine Canon and south of Mustard Ridge, Los Angeles County, in accordance with the plan described in the foregoing opinion as Scheme No. 2 and which is delineated in applicant's Exhibit "A" and provided that applicant's electric power lines at this crossing shall conform to the following specifications:

CLEARANCES.

1. That under the most unfavorable conditions of temperature and loading and with the conductor broken in any adjacent span the minimum clearance of steel tower transmission lines over highway shall be not less than thirty (30) feet above any other electric power, telegraph, telephone or signal circuit, nor less than eight (8) feet at the maximum temperature defined in paragraph 4 (a) (1) below, plus 25° , provided that in no case shall a temperature less than 120° F. be used in determining the deflection.

CONSTRUCTION.

Factors of Safety.

2. The factors of safety in crossing spans shall be understood to be the ultimate unit stress divided by the allowable unit stress and shall be not less than the following:

Conductors	3
Ground Wire	3
Insulators, Insulator supports and Conductors Clamps	3
Guys and Messengers	3
Structural Steel	3
Foundation Depression	3
Foundation Uplift	3

Temperature, Wind and Ice Conditions:

3. (a) The maximum temperature mentioned hereafter shall be understood to be the highest (observed in the shade) which ever existed in the vicinity of the crossing.

(b) The maximum wind velocity mentioned hereafter shall be understood to be the maximum which ever existed (at exposed points) in the vicinity of the crossing.

(c) The maximum ice covering mentioned hereafter shall be understood to be the greatest which ever existed in the vicinity of the crossing at exposed points.

(d) The minimum temperature mentioned hereafter shall be understood to be the minimum which ever existed in the vicinity of the crossing (same elevation) at exposed points.

In the absence of sufficient definite data in regard to the above extremes, the assumption used shall lie within the limits hereinafter specifically prescribed.

LOADING

4. (a) The different portions or units of the crossing span shall each be designed to withstand with the above designated factors of safety, the following conditions of loading, at the minimum temperature defined above, minus 5°, provided that in no case shall a temperature in excess of 10° F. be used, unless continuous official climatological records from the three nearest observation stations of corresponding altitude should justify the use of a higher temperature. The conductors and ground wires shall be considered as uniformly loaded throughout their length, with a load equal to the resultant of the dead load and a wind pressure over the projected area of conductors, due to the maximum velocity as defined in paragraph (3) (b) plus ten (10) miles per hour, provided that in no case shall a velocity less than fifty (50) miles per hour (actual) be used in computing this pressure.

(b) The ice load shall be determined from the maximum ice covering as defined in (3) (c) above, provided that in no case shall a thickness less than one-fourth (1/4) inch be used in computing this load at elevations exceeding 2,500 feet above sea level, nor less than one-half (1/2) inch at elevations exceeding 3,500 feet. This load (4) (a) shall be equal to the weight of conductor and suspended ice (at 57 pounds per cubic foot) and the wind pressure as determined in (4) (a) on the projected area of conductors and ice covering.

(c) Insulators, Clamps, Etc. Insulators, supports, clamps and miscellaneous attachments including guys and messengers shall be designed to withstand, with the designated factors of safety, the tension in conductors, wires or structures under the maximum loading.

(d) Towers. The towers and foundations shall be designed to withstand, with the above designated factors of safety, the combined stresses from their own weight, the wind pressure on the tower and the above designated wire loading on the crossing span and next adjoining span on each side. The wind pressure shall be determined as in (a) and considered as applied over an area one and three-quarters (1-3/4) times one side of the tower, provided that in no case shall a velocity less than fifty (50) miles per hour be used in calculating such pressure.

(e) Foundations. Foundations shall be designed to prevent overturning due to depression or uplift under the most unfavorable conditions of loading, as hereinabove mentioned. The weight of concrete shall be assumed to be 140 pounds per cubic foot and the weight of "earth" (calculated at 30° from the vertical) shall be assumed to be 90 pounds per cubic foot. The back fill shall be thoroughly tamped in approximately eight (8) inch layers.

(f) General. The towers, foundations, insulators, supports, clamps and miscellaneous attachments shall be designed to withstand with the above designated factors of safety, the hereinabove specified loads combined with the unbalanced tension due to the breaking of two (2) conductors for towers carrying four (4) or less three (3) conductors for towers carrying five (5) to eight (8).

5. Splices. The conductors shall not be spliced in the crossing span nor in the adjoining span on either side, except when such splice shall develop a tested strength and conductivity equal to or in excess of those of the uncut conductor, and excepting further that a splice may be introduced in the unstressed or slack portion of conductor between anchor clamps.

6. Insulator Supports. Double insulator supports with separate suspension clamps shall be provided for suspending each conductor from the towers supporting the crossing span. The two suspension clamps shall be spaced not less than 24 inches apart longitudinally.

7. Alternative Construction. In case the allowable maximum mechanical tension in the conductors cannot be made to conform to the factors of safety hereinabove specified or the minimum clearances hereinabove mentioned be maintained without additional support insulated messenger wires may be installed over each conductor and the conductor suitably supported therefrom at such intervals as will, in the event of a broken conductor in the crossing span, or in case undue slack is otherwise introduced, support the conductor in the crossing span and prevent its coming in contact with other lines or wires or materially reducing the minimum clearance over the roadway as specified above.

8. Angles at Crossings. Unless ample provision is made to insure the necessary additional strength to withstand angle strains the towers supporting the crossing span and the adjoining span on each side shall be in a straight line to avoid unnecessary strains at this point.

9. Location of Towers. One tower of each crossing span shall in every instance be located as near the roadway as possible.

10. Electrical Performance of Insulators. Flashover requirements.

(a) The assembled insulator chain, when clean and dry, shall have a flashover voltage not less than the following:

Line Voltage						Flashover Voltage
Exceeding	9,000	but	not	exceeding	14,000	65,000
"	14,000	"	"	"	27,000	100,000
"	27,000	"	"	"	35,000	125,000
"	35,000	"	"	"	47,000	150,000
"	47,000	"	"	"	60,000	180,000
"	60,000	. . . . .				3 times line voltage

The assembled insulator chain, subjected to a precipitation of water of one-fifth of an inch (1/5") per minute, at an inclination of forty-five degrees (45°) to the axis of the insulators, shall have a flashover voltage of not less than:

Line Voltage						Flashover Voltage
Exceeding	9,000	but	not	exceeding	14,000	40,000
"	14,000	"	"	"	27,000	60,000
"	27,000	"	"	"	35,000	80,000
"	35,000	"	"	"	47,000	100,000
"	47,000	"	"	"	60,000	120,000
"	60,000	. . . . .				twice the line voltage

(NOTE) The above are prescribed for suspension or disc type insulators, when the pin or fixed type of insulator is used, the same minimum flashover voltages shall be required for each assembled and cemented insulator.

Test voltages above 35,000 volts shall be determined by the A.I.E.E. Standard Spark-Gap Method.

Test voltages below 35,000 volts shall be determined by transformer ratio.

(b) Puncture. Each insulator unit shall be so designed, that, subjected to excessive potential stress, failure will first occur by flashover and not by puncture.

(c) Protection from Arcing. The insulator chain, as installed, shall be adequately protected against destruction from arcing by properly designed and located discharge gaps.

(d) Elimination of Defective Units. Each insulator unit, when clean and dry shall be subjected to the following tests in the order named. Units which do not meet these requirements shall be rejected.

The unit shall be stressed mechanically by a pull of not less than 5000 Lbs. applied in line with its axis for three (3) seconds. It shall then be subject to a voltage adjusted to a point just below flashover potential which shall be maintained continuously for ten (10) minutes. The insulation resistance shall then be measured. No insulator unit shall be accepted which shows appreciable mechanical distortion or injury, or which punctures during the over voltage test, or which measures less than 5000 megohms insulation resistance.

(e) Field Test. Each insulator unit shall be tested for insulation resistance immediately preceding erection. No unit shall be accepted which has an insulation resistance less than 5000 megohms.

11. Cradles. No cradles or overhead bridges shall be used except where special permission is granted by the Commission.

12. Materials.

(a) Conductors. The conductors shall be of copper, aluminum, or other non-corrodible material except where the required mechanical strength cannot be obtained with the above materials, if properly protected from corrosion, steel cables may be used.

(b) Insulator supports, clamps, and Miscellaneous Attachments. Insulator supports, clamps and miscellaneous attachments shall be of steel, wrought iron, malleable iron, or other approved metal or alloy, and shall be galvanized or otherwise protected from corrosion.

(c) Guys. Guys shall be galvanized or copper covered stranded steel cable, not less than 5/16 inch diameter, or galvanized rolled rods of equivalent tensile strength.

(d) Structural Steel. Structural steel shall be in accordance with the Manufacturer's Standard Specifications.

The design and workmanship shall be strictly in accordance with first class practice.

The form of the frame shall be such that the stresses may be computed with reasonable accuracy, or the strength shall be determined by actual test.

The sections used shall permit inspection, cleaning and painting, and shall be free from pockets in which water or dirt can collect.

The length of a main compression member shall not exceed 180 times its least radius of gyration. The length of a secondary compression member shall not exceed 220 times its least radius of gyration.

The minimum thickness of metal in galvanized structures shall be one-quarter inch (1/4") for main members and one-eight inch (1/8") for secondary members. The minimum thickness of painted material shall be one-quarter inch (1/4").

13. Records. Drawings showing correctly towers, supports, clamps, miscellaneous attachments, etc., specifications covering concrete, steel, conductors, towers, insulators and protective coatings; sketches showing roadway, clearance, tower spacing and foreign lines; a complete statement of the actual unit factors of safety at each crossing, together with a record of the maximum and minimum temperatures the maximum wind velocity and ice-covering used in calculating stresses shall be filed in duplicate with the Commission at least thirty (30) days before the line is placed in operation.

The foregoing opinion and order are hereby approved and ordered filed as the opinion and order of the Railroad Commission of the State of California.

Dated at San Francisco, California, this 19th day of June, 1916.

Max Thelen

H. D. Loveland

Alex Gordon

Edwin O. Edgerton

Commissioners.