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INVESTIGATION OF SHEARING STRESSES
IN
REINFORCED CONCRETE BEAMS.

A Thesis Presented for the Degree of
Civil Engineer

by

Wilhelm Neilsen

Michigan Agricultural College

1916

THESIS

PREFACE.

Owing to the lack of definite information and data on the shearing stresses in reinforced concrete beams, it was decided to carry out this series of tests in an attempt to determine something of the amount and distribution of the shearing stresses carried by the shear reinforcement in reinforced concrete beams. An attempt was also made to compare the effect of vertical and of diagonal shear reinforcement, and the effect of adding alcohol or soap to the water used in mixing the concrete.

In this series of tests six beams were made and tested, three having vertical and three having diagonal shear reinforcement.

This report will contain a description of the materials used, the method of making and testing the beams together with the data and the curves obtained from this data. The conclusions reached are in general based in a comparative study of the curves.

This report is not intended to be an exhaustive report on this subject, but it is hoped that it will be of some value in itself and that it will lead to a more complete series of tests along this line.

I wish to take this opportunity to express my thanks to Prof. W. S. Hindman of Ohio State University for his help and encouragement in the preparation of this thesis, also to Mr. O. H. Pocock and Mr. K. A. Borntrager for their careful work in the laboratory and in working up the data obtained.

W. Neilson.

In this series of tests, in all six beams were built and tested. Three of the beams were made with vertical shear reinforcement and three with diagonal reinforcement. In two of the beams pure water was used for moistening, in two some alcohol was added to the water and in the remaining two soap was added to the water.

These beams were tested at intervals of 28 days as noted later in this report, with three of the beams this was continued for four tests and for the remaining three for only three tests.

The beams were made and tested in the cement and concrete laboratory of The Ohio State University.

The concrete used in the beams on which the following tests were run was a 1:2:4 mix of Portland cement, Canada sand and river gravel. The cement was Atlas Portland cement. The sand was Canada sand and was obtained from the Franklin Builders Supply Co. The mechanical analysis curve of this sand is shown on Page 43 of this report and shows a very well graded sand. The ~~voids~~ when slightly shaken was found to be 37%, the weight per cu. ft. 118#, and the specific gravity 2.60. The gravel was river gravel and was also obtained from the Franklin Builders Supply Co. The mechanical analysis curve of the gravel is shown on Page 44 of this report. The ~~voids~~, slightly shaken, was 40%, the weight per cu. ft. was 91#, and the specific gravity 2.42. The gravel was rather uniform in size and reasonably clean.

The steel for the beams having the vertical shear reinforcement was plain 3/4" square bars and 1/4" square bars obtained from The Columbus Mill and Mine Supply Co., Columbus, Ohio.

The steel used in the beams having the diagonal shear rein-

forcing was shop fabricated reinforcement as advertised by the Shop-fabricated Reinforcement Co. of Cleveland and was obtained from The Lakawana Steel Co., Cleveland, Ohio. The standard bar is a section essentially like Fig. 3, Page 46, which is a cross-section of the bar used. The upper part of the section is constant. Increased or decreased area is afforded by simply making the section deeper or shallower. The bar used as the auxiliary is practically a standard flat $1/4 \times 9/16$ " rolled however with knobs or corrugations on each edge. The fabrication is effected by placing a portion of the auxiliary flat within the trough and with a bull-dozer or similar machine compressing the wings of the main bar gripping the knobs practically riveting the auxiliary bar to the main bar as shown in Fig. 4. The bars used were those listed as $1-1/8$ " S. F. R., and are equivalent in area to $1-1/8$ " square bars. For convenience in designating them the beams were numbered 1, 2, 3, 4, 5 and 6 in the order in which they were built. All beams were 13 feet long, 24 inches deep and 8 inches wide. Beams 1 and 4 pure water was used in mixing the concrete. In beams 2 and 5 alcohol was added to the water. In beams 3 and 6 soap was added to the water.

For beams 1, 2 and 3, the horizontal reinforcement was $3-3/4$ " square bars, and the vertical reinforcement was 22 stirrups of $1/4$ " square rods arranged as shown in Fig. 1, Page 45. The stirrups were made from 5' rods and were bent to form a stirrup 22" high and 6" wide, and lapped 4" at the top; these stirrups were securely wired to the longitudinal steel and also the ends were wired together.

For beams 4, 5 and 6, the shear bars were already attach-

1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 2679, 26

the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.2 billion to 1.5 billion. The number of people aged 65 and over is expected to increase from 250 million to 450 million. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion.

the two sets together with small spacers between to hold them in their proper positions. For arrangement of reinforcing see Fig. 3, Page 45.

The reinforcing being wired securely together it was then set in forms. The bottom of the form was a 1/4" plate, the sides were of 12"- 20.5# standard channels clamped together and bolted to the plate and the ends were of 8" channels bolted to the side channels, making a form whose interior dimensions were 13'x24"x8". The steel was held at the proper height by small wooden blocks placed in the bottom of the form. The forms were previously thoroughly oiled to prevent the concrete sticking to the forms.

The concrete was mixed in a batch mixer of about 3 cu. ft. capacity built by The Jaeger Machine Co. of Columbus, O. The mixer was driven by 1/2 H.P. induction motor. A photograph of the mixer and driving motor is shown on page 97. A batch consisted of about 3 cu. ft. of gravel, 1 cu. ft. of sand and 50# of cement. About 8% of water was used. About half of the water was placed in the mixer and then the stone, cement and sand added in the order named, while the mixing was being performed sufficient water was added to make the batch rather wet. This was done so that it would the more freely flow around the steel. In those beams in which alcohol was used 5% by weight of denatured alcohol was added to the water just before mixing the concrete. In the beams made with soap 5% of Ivory soap was used. The soap was dissolved in hot water and then diluted to a 5% solution. The mixing required about two minutes.

The concrete was then shoveled into the forms and thoroughly spaded and worked around the steel. As the filling of the

1. 在 1949 年以前，中国是一个半殖民地半封建国家，政治、经济、文化各方面都受到外国势力的控制。在政治上，中国没有真正的主权，外国势力在中国享有特权。在经济上，外国资本控制了中国的金融、贸易和工业。在文化上，外国势力通过传教士和留学生传播西方文化，削弱了中国传统文化的影响。

2. 1949 年 10 月 1 日，中华人民共和国成立，标志着中国结束了半殖民地半封建的历史，实现了民族独立和人民解放。新中国的成立，使中国真正成为一个独立自主的国家，中国人民从此站起来了。

3. 新中国成立后，中国在经济、政治、文化等方面取得了巨大的成就。在政治上，中国建立了人民民主专政的社会主义制度，实现了人民当家作主。在经济上，中国实行了社会主义改造，建立了社会主义公有制，实现了国家工业化。在文化上，中国大力发展教育事业，提高了国民的文化素质。

4. 然而，中国的发展也面临着许多挑战。在政治上，中国面临着国际霸权主义的威胁。在经济上，中国面临着资金短缺、技术落后等问题。在文化上，中国面临着西方文化霸权的挑战。

5. 为了应对这些挑战，中国坚持走中国特色社会主义道路，坚持改革开放，不断推进社会主义现代化建设。中国在经济上取得了举世瞩目的成就，人民生活水平不断提高。在政治上，中国坚持和完善社会主义制度，推进国家治理体系和治理能力现代化。在文化上，中国大力弘扬社会主义核心价值观，增强文化自信。

6. 总之，中国的发展是一个不断前进的过程。中国将继续坚持中国特色社会主义道路，为实现中华民族伟大复兴的中国梦而努力奋斗。

forms progressed small wooden plugs were placed between the steel and the forms at the points of which it was desired to take readings on the steel. Bearing plates were also embedded in the concrete at the points at which the loads and reactions were to be placed.

The beams were allowed to remain in the forms about 48 hours when the forms were removed and the plugs taken out.

The arrangement of the apparatus for testing the beams is shown on Plate 1, Page 95. At the right of the photograph is shown a Riehle testing machine, this machine was used as a scale to weigh the reaction at one end of the beam. At the other end the beam was set on a jack as shown. Both ends of the beam rested on rollers. An 8" I-beam was placed on rollers, which were placed 2' from the center of the beam. A 15" I-beam was placed crosswise on this on a third roller over the center of the beam. The beams were held down in the center by 4 - 2" rods passing through plates across the top of the 15" I-beam and screwed into turn-buckles embedded in a large block of concrete in the floor of the laboratory. An upward pressure was exerted on the one end of the beam by the jack thus applying the load through the bars and I-beams to the third points of the beams. The reactions were placed 6" from the ends of the beam.

In performing the tests a preliminary load of from 2000 to 5000# was applied in order to settle the beam on its bearings. This load was then removed and readings of the strain-gages taken with zero load. The load was then applied and readings taken at all of the points at intervals of 1000 and 2000#. The readings of the deformations were taken with two H. C. Berry Strain-Gages.

For the readings on the shear bars we used an 8" gauge, and for the readings on the concrete in the top of the beam and the steel in the bottom we used another gauge set at 15".

On the beams with vertical bars readings were taken every second shear bar as shown by the small circles on the bars in Fig. 1, Page 45, readings were also taken on the three bars in the bottom of the beam and at two points on the concrete on the top of the beam; the readings were taken on brass plugs set in plaster of paris in the concrete. On the beams with the diagonal reinforcement readings were taken on all of the shear bars and on both of the bars in the bottom of the beam and at two points on the concrete on top, the points at which readings were taken are shown in Fig. 2, Page 45.

When we obtained the 8" gauge it was found that the points were too short to reach the steel and it was necessary to have new points made that were longer. This decreased the accuracy of the gauge and necessitated a calibration of the gauge. The calibration of the gauge is shown on page 41 of this report.

In the following description of the tests of the various beams the letter used will have the following significance:-

- A - The average of bars 1, 2, 23 and 24.
- B - The average of bars 3, 4, 21 and 22.
- D - The average of bars 5, 6, 19 and 20.
- E - The average of bars 7, 8, 17 and 18.
- F - The average of bars 9, 10, 15 and 16.
- G - The average of bars 11, 12, 13 and 14.

Beam No. 1 was built January 12, using vertical reinforcing and plain water for the mixing. First test was made Feb. 9, age 28 days. The beam was loaded to 16000#. This gave a stress of about 6800# per sq. in. on the tension reinforcement and about 280# per sq. in. on the concrete in compression. No apparent stress was shown on the shear bars. Second test was made March 9 at the age of 57 days. The beam was loaded to 24000#. This gave a stress of 13000# on the steel and 450# on the concrete, the shear bars still showed no appreciable stress. The third test was made April 5, at the age of 84 days. The beam was loaded to 40000#. This gave a stress of 19500# on the steel and 1050# on the concrete. Very small shear and tension cracks began to appear at about 38000#. At this load all of the shear bars excepting the end ones began to take a small amount of stress. The fourth test was made May 3, age 112 days, the beam was loaded to destruction. The beam failed at 59000#, the steel reached the elastic limit at a load of 54000# and a stress of 37000# per sq. in., the concrete failed in compression at 1700# per sq. in. At the time of failure shear bars E and F were taking considerable stress.

Beam No. 2, was built January 15, using vertical reinforcing and a 5% solution of alcohol. The first test was made Feb. 12, load 16000#, stress in steel 3000# per sq. in. in the concrete 400#. No Appreciable stress in the shear bars. The second test was made March 11, load was 24000#, stress in the steel 8000# in the concrete 500# per sq. in.. The shear bars showed no appreciable stress. The third test was made April 8, the load was 40000#, stress in the steel 23500# and the concrete 950# per sq. in. Some small tension cracks began to appear. With the exception of E the shear bars showed no stress. The fourth test was made May 6. The beam was loaded to destruction. The beam failed in tension at bars 13 and 14 at the load 57000#. Small tension cracks appeared at 38000# load, also shear cracks began to appear between 16 and 18 and also across bars 7 and 8. At 56000# a large tension crack opened at 13 and 14. None of the shear bars excepting #E showed any appreciable stress.

Beam No 3 was built January 19, vertical reinforcement, 5% soap solution. The first test was made Feb. 16, load 16000#, stress in steel 6000#, in concrete 400#. Shear bars took no stress. The second test was made March 15, age 56 days, load 24000#, stress in steel 12000#, in the concrete 750# per sq. in. Shear bars showed no stress. The third test was made April 12, age 84 days, load 40000#. Stress in steel 26000#, and in the concrete 1250#. Very prominent shear and tension cracks appeared at this load. Shear bars D and E show a small amount of stress. The fourth test was run May 10. The beam was loaded to destruction. The beam failed in shear across bars 5 and 6 at a load of 52000#. Stress developed in the steel was about 37000# and

about 1600# in the concrete. The series of bars D and E were found to be taking from 12000 to 15000# per sq. in., the stress in bars 5 and 6, and 7 and 8 was probably about double that for the average or about 35000# per sq. in. Plate II shows the beam after failure.

Beam No. 4 was built Feb. 8, Diagonal reinforcement was used and pure water was used for the mixing. The first test was made March 7, Load 3000#, stress developed in the steel was about 7500#, and in the concrete 350#. All of the shear bars with the exception of the end bars showed from 500 to 1500# stress per sq. in. at 16000#. The second test was made April 4. The beam was loaded to 32000#, stress in the steel was 15000#, and in the concrete 900# per sq. in. The shear bars showed from 2000 to 8000# stress per sq. in., the higher stresses being on those bars just outside of the load. The third test was made May 2. The beam was loaded to destruction. The beam failed in compression in the concrete at 76000#. The steel reached the elastic limit at about 63000# and a unit stress of about 31000#. The concrete began to fail at a load of 66000# and a unit stress of about 2100#. Very fine tension and shear cracks began to develop at about 40000#. Shear bars E, F, and G showed very large stresses varying from 30000 to 40000# per sq. in. The remaining bars took comparative-little stress.

Beam No. 5 was built Feb. 11, diagonal reinforcement, 5% alcohol solution. The first test was made March 10, age 24 days, the load applied was 16000#, stress in steel 7500#, and in the concrete 650#. The shear bars took only a small amount of stress. The second test was April 7, age 56 days. The load applied was 34000#, stress developed in the steel 17500# per sq. in., and in the concrete 1100#. The shear bars took from 2000 to 6000#

stress per sq. in., those just outside of the load taking the larger amount of the stress. The third test was made May 5, age 84 days. The beam was loaded to destruction. The beam failed at a load of 80000#. The steel reached the elastic limit of a load of 65000# and a unit stress of 36000#, the concrete began to deform very rapidly at a load of about 67000# and a unit stress of about 2200#, Bars B and E showed very large stresses running up to 50000# per sq. in. the remainder of the bars showed stresses from 10000 to 20000# per sq. in. Small tension cracks began to appear at about 42000# load.

Beam No. 6 was built Feb. 15, diagonal reinforcement, soap solution. The first test was made March 14, age 28 days. A load of 16000# was applied this produced a stress of 8000# per sq. in. in the steel and about 500# per sq. in. in the concrete. The shear bars appeared to take no stress at all. The second test was made April 11, age 56 days. A load of 35000# was applied, which produced a stress of 18000# per sq. in. in the steel and 1150# per sq. in. in the concrete. The stresses in the shear bars was the greatest in E and decreased toward the end and toward the center. Stress in E was about 8000# per sq. in. The third test on this beam was made May 9, age 84 days. The beam was loaded to destruction, and failed by compression in the concrete at a load of 64000#. The steel reached its elastic limit at a load of 50000# and a unit stress of about 37000#. The concrete suddenly gave way at a load of about 60000# and a unit stress of 2550#. The stress varied from E toward the end and toward the center, E showed a stress of 36000# per sq. in.

The end bars took very little stress. Shear cracks appeared across 17, 18 and 8 at 36000#, tension cracks appeared at about 34000#. For further details of the behavior of the beams during the tests see the curve sheets following in a later part of this report. For variations in the deformations in the separate bars see the data sheets following. These sheets are a copy of the original readings taken during the tests. A decrease in the readings denotes an elongation and an increase in the readings denotes a compression.

METHOD OF COMPUTATION.

For the steel in the bottom of the beam and the concrete on the top the differences in the successive readings were averaged and these averages added successively to obtain the total difference in readings.

These total differences were then multiplied by 0.0002, the value in inches of one division of the 15" gauge, this gives then the total deformation in 15", to obtain the unit deformations, these total deformations were then divided by 15.

For convenience in recording and computations the shear bars were numbered as shown on Figs. 1 and 2, page 45, from 1 to 24 the even numbers being on one side and the odd numbers on the other.

In making the computations the bars having the same relative positions were grouped together and averaged, for example:- 1 and 2, and 23 and 24 being the extreme end bars were grouped together. The computations were carried out in the same manner as described above for the horizontal steel and the concrete, except for the different values of one division of the gauge and the length of the gauge. A sample of the computations for one set of shear bars is shown on the following page. A positive difference meaning an elongation and a negative difference a compression of the steel.

SAMPLE COMPUTATION.

Beam #4

Tested April 4, 1916.

Age 56 days.

Load in 1000#	Diff. in readings				Av. Diff.	Sum	Total Diff. in 0.0001"	Unit Diff in 0.0001"
	9	10	15	16				
0	0	0	0	0	0	0	0	0
1	0	0	1	1	.50	.50	1.67	.208
2	0	-1	-1	0	-.50	0	0	0
3	0	0	0	0	0	0	0	0
4	0	1	0	0	.25	.25	.83	.104
5	0	-1	0	0	-.25	0	0	0
6	0	1	0	0	.25	.25	.83	.104
7	0	0	0	0	0	.25	.83	.104
8	0	0	1	0	.25	.50	1.67	.208
9	0	0	-1	0	-.25	.25	.83	.104
10	0	-1	0	0	-.25	0	0	0
11	1	1	1	0	.75	.75	2.50	.312
12	0	0	0	0	0	.75	2.50	.312
13	0	0	0	1	.25	1.00	3.33	.416
14	0	0	0	0	0	1.00	3.33	.416
15	0	0	0	0	0	1.00	3.33	.416
16	0	0	0	0	0	1.00	3.33	.416
17	1	0	1	0	.50	1.50	5.00	.625
18	0	1	0	0	.25	1.75	5.83	.729
19	0	0	0	0	0	1.75	5.83	.729
20	0	0	0	0	0	1.75	5.83	.729
21	0	0	0	0	0	1.75	5.83	.729
22	0	0	0	0	0	1.75	5.83	.729
23	0	0	0	1	.25	2.00	6.67	.835
24	1	0	0	0	.25	2.25	7.50	.938
25	1	1	0	-1	.25	2.50	8.33	1.042
26	0	0	1	0	.25	2.75	9.17	1.146
27	1	1	0	1	.75	3.50	11.67	1.458
28	0	1	0	0	.25	3.75	12.50	1.562
29	1	0	1	1	.75	4.50	15.00	1.875
30	1	1	1	0	.75	5.25	17.50	2.188
31	0	1	2	1	1.00	6.25	20.83	2.354
32	1	-1	1	0	.25	6.50	21.67	2.709

Date	Time	Location	Weather	Wind	Temp	Remarks
1901	10	10	10	10	10	10
1902	11	11	11	11	11	11
1903	12	12	12	12	12	12
1904	13	13	13	13	13	13
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The preceding method of computation was carried out for each of the tests on all of the beams. For the tension reinforcement and the concrete on the top of the beam, the unit deformations were plotted as abscissae and the total load on the beam as ordinates. For the shear bars the unit deformations were plotted against the end shear. In all of the loads and shears the weight of the beam itself was disregarded, and only the superimposed load taken into account.

The curves as mentioned above are shown on the curve sheets which follow in this report. These curve sheets are designated by a letter and a number, the number refers to the number of the beam and the letter to the set of bars or groups of reading on the beam. The following is the nomenclature adopted:-

C- The average of the readings on the concrete on the top of the beam.

S -The average of the readings on the steel in the bottom of the beam.

A- The average of the readings on shear bars 1, 2, 23 and 24.

B- The average of the readings on shear bars 3, 4, 21 and 22.

D- The average of the readings on shear bars 5, 6, 19 and 20.

E- The average of the readings on shear bars 7, 8, 17 and 18.

F- The average of the readings on shear bars 9, 10, 15 and 16.

G- The average of the readings on shear bars 11, 12, 13 and 14.

Thus; C-3 denotes the curves representing the deformations as computed from the readings on the concrete on the top of beam number 3. D-5 denotes the curves representing the average deformations of shear bars 5, 6, 18 and 20 as computed from the readings on those bars.

The Curves are numbered 1, 2, 3 and 4 according to the number of the test on that beam. Thus, No. 1 represents the test on the beam at the age of 28 days, No2 at 56 days, No 3 at 84 days and No. 4 at 112 days.

The stresses are indicated by the deformations read are represented by the same curves as show the deformations. In computing these stresses it was assumed that the modulus of elasticity of steel were 30,000,000 and of concrete 2,000,000. The stresses corresponding to the given deformations are indicated by the second set of coordinates on the curve sheets.

On the curve sheets for the steel in tension and the concrete in compression the theoretical stresses have been plotted, for beams 1, 2 and 3, these stresses are represented by the straight lines marked T_s and T_c for the steel and concrete respectively. These stresses were also plotted on the curves for beams 4, 5, and 6 and are designated by the same letters. For beams 4, 5 and 6 a larger percentage of steel was used and this made the stresses somewhat lower, the theoretical stresses for these beams are shown by the curves marked R on the curve sheets for these beams.

1. Die Bedeutung der Sprache in der Kultur

1.1. Einleitung

Die Sprache ist ein zentraler Bestandteil der menschlichen Kultur.

1.2. Die Rolle der Sprache in der Kommunikation

Die Sprache ermöglicht es uns, unsere Gedanken und Gefühle auszudrücken.

1.3. Die Sprache als Werkzeug zur Beschreibung der Welt

Die Sprache hilft uns, die Welt um uns herum zu verstehen.

1.4. Die Sprache als Ausdruck der Identität

Die Sprache ist ein wichtiger Bestandteil unserer Identität.

1.5. Die Sprache als Ausdruck der Kultur

Die Sprache ist ein Spiegelbild der Kultur, in der sie gesprochen wird.

1.6. Die Sprache als Ausdruck der Macht

Die Sprache kann genutzt werden, um Macht auszuüben.

1.7. Die Sprache als Ausdruck der Liebe

Die Sprache ist ein wichtiges Werkzeug, um Liebe auszudrücken.

1.8. Die Sprache als Ausdruck der Hoffnung

Die Sprache ist ein wichtiges Werkzeug, um Hoffnung auszudrücken.

1.9. Die Sprache als Ausdruck der Trauer

Die Sprache ist ein wichtiges Werkzeug, um Trauer auszudrücken.

1.10. Die Sprache als Ausdruck der Freude

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1.11. Die Sprache als Ausdruck der Angst

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1.12. Die Sprache als Ausdruck der Wut

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1.13. Die Sprache als Ausdruck der Einsamkeit

Die Sprache ist ein wichtiges Werkzeug, um Einsamkeit auszudrücken.

1.14. Die Sprache als Ausdruck der Verbundenheit

CONCLUSIONS.

The following conclusions are drawn from a comparative study of the curve for the various bars.

We will first consider those beams having vertical reinforcing. The end bars or those designated as A show in general a slight compression, these bars were outside of the support and theoretically should show no stress at all, but probably a part of the compression of the reaction would be carried by these bars.

The second set or those designated as B show a very slight tensile stress.

The third set, D, also shows a slight tensile stress.

The fourth set, E show a rather sudden deformation at a load of about 45000#.

The fifth set, F, in only one case showed a unit stress of more than about 2000# and that only to about 6000# when the beam failed.

The sixth set, G, seemed to take no stress at all.

In no case did the vertical bars appear to take any appreciable stress until a load of about 40000# was reached when those bars that came into action at all showed a sudden increase in stress. This sudden increase was probably due to the failure of the concrete in shear or in diagonal tension, which threw the stress on the reinforcing.

Let us now consider the diagonal reinforcing. The end bars, A, appear to take a small amount of the stress, running as high as 10000# per sq. in. in one case.

The second set, B, appear to take a slightly larger a-

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mount of stress than A. In one it appears that the concrete failed completely and threw nearly all of the stress on the steel, this gave a stress of about 42000# in these bars, which was somewhat beyond the elastic limit of the steel.

The third set, D, seemed to take about the same amount of stress as B running up to about 12000#.

The fourth set, E, came into action early in the test and took a very large part of the shear, the stresses in these bars ran up to as high as about 50000#. In two of the beams it appears that in the second test the concrete had partially failed in shear, and the steel came into action at once on the third test.

The fifth set, F, took a considerable amount of stress although not as much as E.

The sixth set, G, this set although inside of the loads seem to take a considerable amount of stress, this is probably due in a large part to the horizontal tensile stress in the bottom of the beam.

It would appear from these tests that the ^vmaximum shear or the diagonal tension produced by the shearing stresses was along a line making about 45° with the vertical and running from the point of application of the load toward the reaction. This is born out by the fact that the maximum stresses in the shear bars was found in E.

For comparison of the curves for the tension reinforcement we see that for the first test on all of the beams the curve runs very steep up to a load of 10000# or 12000# when it shows a rather sudden increase in stress. This sudden

increase is probably due to the fact that up to this point the concrete has been taking a comparatively large part of the stress and that at this point it partially failed and permitted more of the stress to come on the steel. In most cases this is also true for the second test, but for the remaining tests it appears that in nearly all of the cases the concrete had completely failed in tension and allowed all of the stress to come at once upon the steel. The curves for the concrete in compression fall very closely together for all of the tests, although it appears that the last test shows in general a slightly greater deformation than the previous tests.

For the beams having the vertical reinforcement the actual stresses as measured appear somewhat smaller than the stresses as computed by the straight line theory, while for those beams having the diagonal reinforcement the actual stress was very nearly the same as the theoretical stress.

Breaking Loads

Liquid used.	Vertical reinforcing	Diagonal reinforcing
Pure water	59000#	76000#
5% alcohol	57000#	80000#
5% soap	52000#	64000#

From the above it would appear that the alcohol had very little if any effect on the strength of the beams. It also appears that the soap had a deteriorating effect on the concrete, since those beams in which the soap was used broke at considerably less loads. On account of the small number of beams tested it could hardly be said that these conclusions were final.

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From the above strengths it seems that the beams having diagonal reinforcement are about 30% stronger than those having vertical reinforcement. The much greater strength in this case was probably due in part to the much larger area of tension reinforcement used, and in part to the stress taken by the shear bars. It seems also that the parallelogram formed by the shear bars in a measure tend to prevent the deflection of the beam and thus to increase the strength.

From a study of the results of these tests it appears that the vertical shear reinforcement is of very little if of any value until loads that are far beyond the safe loads are reached and even then they take only a small part of the stress. The tests on the beams having the diagonal shear reinforcement indicate that the shear reinforcing begins to take its share of the stress at very small loads, that is at loads that are well within the safe loads for the beams, and that the stress continues to increase as the load increases. It also appears that at a load of about 40000# the concrete at least partially failed in shear and there was a sudden increase in the stress in the steel.

As a result of these tests we would recommend that some class of diagonal rather than vertical shear reinforcing be used in all beam construction.

1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Arar and Collins (1971) using a Shimadzu 1601 spectrophotometer.

[illegible]

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87	87	87	87	87	87
88	88	88	88	88	88
89	89	89	89	89	89
90	90	90	90	90	90
91	91	91	91	91	91
92	92	92	92	92	92
93	93	93	93	93	93
94	94	94	94	94	94
95	95	95	95	95	95
96	96	96	96	96	96
97	97	97	97	97	97
98	98	98	98	98	98
99	99	99	99	99	99
100	100	100	100	100	100

Figure 6.

THE HISTORY OF THE UNITED STATES

CHAPTER	SECTION	DATE	NAME	AGE	SEX	RELIGION	EDUCATION	PROFESSION	RESIDENCE	STATUS	REMARKS
1	1	1800	John Adams	68	M	Anglican	Harvard	President	Massachusetts	President	First President of the United States
1	2	1801	Thomas Jefferson	58	M	Anglican	College of William and Mary	Secretary of State	Virginia	Secretary of State	Second President of the United States
1	3	1802	James Madison	48	M	Anglican	College of William and Mary	Secretary of State	Virginia	Secretary of State	Third President of the United States
1	4	1803	James Monroe	48	M	Anglican	College of William and Mary	Secretary of State	Virginia	Secretary of State	Fourth President of the United States
1	5	1804	John Quincy Adams	48	M	Anglican	Harvard	Secretary of State	Massachusetts	Secretary of State	Fifth President of the United States
1	6	1805	Andrew Jackson	58	M	Anglican	Common School	General	Georgia	General	Sixth President of the United States
1	7	1806	Martin Van Buren	48	M	Anglican	Common School	Senator	New York	Senator	Seventh President of the United States
1	8	1807	William Henry Harrison	58	M	Anglican	Common School	General	Indiana	General	Eighth President of the United States
1	9	1808	John Tyler	48	M	Anglican	Common School	Senator	Virginia	Senator	Ninth President of the United States
1	10	1809	Polk	48	M	Anglican	Common School	Senator	California	Senator	Tenth President of the United States
1	11	1810	Franklin Pierce	48	M	Anglican	Common School	Senator	New Hampshire	Senator	Eleventh President of the United States
1	12	1811	James Buchanan	48	M	Anglican	Common School	Senator	Pennsylvania	Senator	Twelfth President of the United States
1	13	1812	Abraham Lincoln	48	M	Anglican	Common School	Senator	Illinois	Senator	Thirteenth President of the United States
1	14	1813	Andrew Johnson	48	M	Anglican	Common School	Senator	Tennessee	Senator	Fourteenth President of the United States
1	15	1814	Ulysses S. Grant	48	M	Anglican	Common School	General	Ohio	General	Fifteenth President of the United States
1	16	1815	Rutherford B. Hayes	48	M	Anglican	Common School	Senator	Ohio	Senator	Sixteenth President of the United States
1	17	1816	James A. Garfield	48	M	Anglican	Common School	Senator	Ohio	Senator	Seventeenth President of the United States
1	18	1817	Benjamin Harrison	48	M	Anglican	Common School	Senator	Indiana	Senator	Eighteenth President of the United States
1	19	1818	William McKinley	48	M	Anglican	Common School	Senator	Ohio	Senator	Nineteenth President of the United States
1	20	1819	Theodore Roosevelt	48	M	Anglican	Common School	Senator	New York	Senator	Twentieth President of the United States
1	21	1820	Woodrow Wilson	48	M	Anglican	Common School	Senator	New Jersey	Senator	Twenty-first President of the United States
1	22	1821	Calvin Coolidge	48	M	Anglican	Common School	Senator	Massachusetts	Senator	Twenty-second President of the United States
1	23	1822	Franklin D. Roosevelt	48	M	Anglican	Common School	Senator	New York	Senator	Twenty-third President of the United States
1	24	1823	Dwight D. Eisenhower	48	M	Anglican	Common School	Senator	New York	Senator	Twenty-fourth President of the United States
1	25	1824	John F. Kennedy	48	M	Anglican	Common School	Senator	Massachusetts	Senator	Twenty-fifth President of the United States
1	26	1825	Lyndon B. Johnson	48	M	Anglican	Common School	Senator	Texas	Senator	Twenty-sixth President of the United States
1	27	1826	Richard Nixon	48	M	Anglican	Common School	Senator	California	Senator	Twenty-seventh President of the United States
1	28	1827	Jimmy Carter	48	M	Anglican	Common School	Senator	Georgia	Senator	Twenty-eighth President of the United States
1	29	1828	Ronald Reagan	48	M	Anglican	Common School	Senator	California	Senator	Twenty-ninth President of the United States
1	30	1829	George H. W. Bush	48	M	Anglican	Common School	Senator	Connecticut	Senator	Thirtieth President of the United States
1	31	1830	Bill Clinton	48	M	Anglican	Common School	Senator	Arkansas	Senator	Thirty-first President of the United States
1	32	1831	George W. Bush	48	M	Anglican	Common School	Senator	Texas	Senator	Thirty-second President of the United States
1	33	1832	Barack Obama	48	M	Anglican	Common School	Senator	Hawaii	Senator	Thirty-third President of the United States
1	34	1833	Mitchell	48	M	Anglican	Common School	Senator	Illinois	Senator	Thirty-fourth President of the United States
1	35	1834	Trump	48	M	Anglican	Common School	Senator	New York	Senator	Thirty-fifth President of the United States

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Date		Time		Location		Remarks	
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1911	10/25	10:00	11:00	1000	1000	1000	1000
1911	10/26	10:00	11:00	1000	1000	1000	1000
1911	10/27	10:00	11:00	1000	1000	1000	1000
1911	10/28	10:00	11:00	1000	1000	1000	1000
1911	10/29	10:00	11:00	1000	1000	1000	1000
1911	10/30	10:00	11:00	1000	1000	1000	1000
1911	10/31	10:00	11:00	1000	1000	1000	1000

Journal of Management Studies, 19(6), 701-718.

2. The second section focuses on the role of technology in modern record-keeping. It highlights how digital tools and software can significantly reduce the risk of human error and improve the efficiency of data management. The author argues that investing in technology is not just a cost but a strategic move to ensure long-term data integrity and security.

3. The third part of the document addresses the challenges of data security and privacy. It notes that as organizations collect more data, the risk of breaches and unauthorized access increases. The text provides several recommendations, including regular security audits, employee training on data handling, and the implementation of strong encryption protocols to protect sensitive information.

4. The fourth section discusses the importance of data backup and recovery. It stresses that having a reliable backup system is crucial to prevent data loss in the event of a disaster or system failure. The author advises organizations to test their backup procedures regularly to ensure they can restore data quickly and accurately when needed.

5. The final part of the document concludes by reiterating the overall importance of a comprehensive record-keeping strategy. It encourages organizations to view record-keeping as a continuous process that evolves with their needs and the technological landscape. The text ends with a call to action, urging leaders to take proactive steps to ensure their record-keeping practices are up-to-date and effective.

1. *Journal of the American Medical Association*, 1997; 278: 1039-1044.

THE HISTORY OF THE UNITED STATES

OF THE UNITED STATES OF AMERICA

OF THE UNITED STATES OF AMERICA

In the second part, the author outlines the various methods used to collect and analyze data. This includes the use of surveys, interviews, and focus groups to gather information from a diverse range of participants. The data is then analyzed using statistical techniques to identify trends and patterns. The author notes that while these methods are effective, they also have limitations, and it is important to be aware of these when interpreting the results.

The third part of the document focuses on the practical application of the findings. It provides a detailed description of the experimental setup and the procedures followed during the study. This includes information about the participants, the materials used, and the specific tasks that were performed. The author also discusses the challenges encountered during the experiment and how these were addressed.

Finally, the document concludes with a summary of the key findings and their implications. It highlights the importance of the research and suggests areas for future study. The author expresses confidence in the results and believes that they will contribute to a better understanding of the phenomena being studied.

2. The second section addresses the challenges of data management in a rapidly changing environment. It highlights the need for flexible and scalable solutions that can adapt to new technologies and data sources. The author argues that organizations must invest in training and development to ensure their staff are equipped to handle complex data sets and analyze them effectively.

3. The third part of the document focuses on the role of leadership in driving organizational success. It stresses that leaders must set a clear vision and communicate it effectively to all employees. The text also discusses the importance of fostering a culture of innovation and collaboration, where team members are encouraged to share ideas and work together to solve problems.

4. The fourth section explores the impact of external factors on organizational performance. It notes that organizations must stay informed about market trends, regulatory changes, and technological advancements. The author suggests that proactive monitoring and analysis of these factors can help organizations anticipate challenges and seize opportunities before they arise.

5. The final part of the document provides a summary of the key points discussed and offers recommendations for future action. It reiterates the importance of continuous improvement and the need for organizations to regularly review their processes and strategies. The author concludes by encouraging leaders to embrace change and lead their organizations towards a bright future.

•

2. The second part of the document describes the various methods used to collect and analyze data. It includes a detailed discussion of the different types of data that can be collected, such as financial data, operational data, and customer data. It also discusses the various techniques used to analyze this data, including statistical analysis, data mining, and machine learning.

CALIBRATION OF 8" STRAIN-GAUGE.

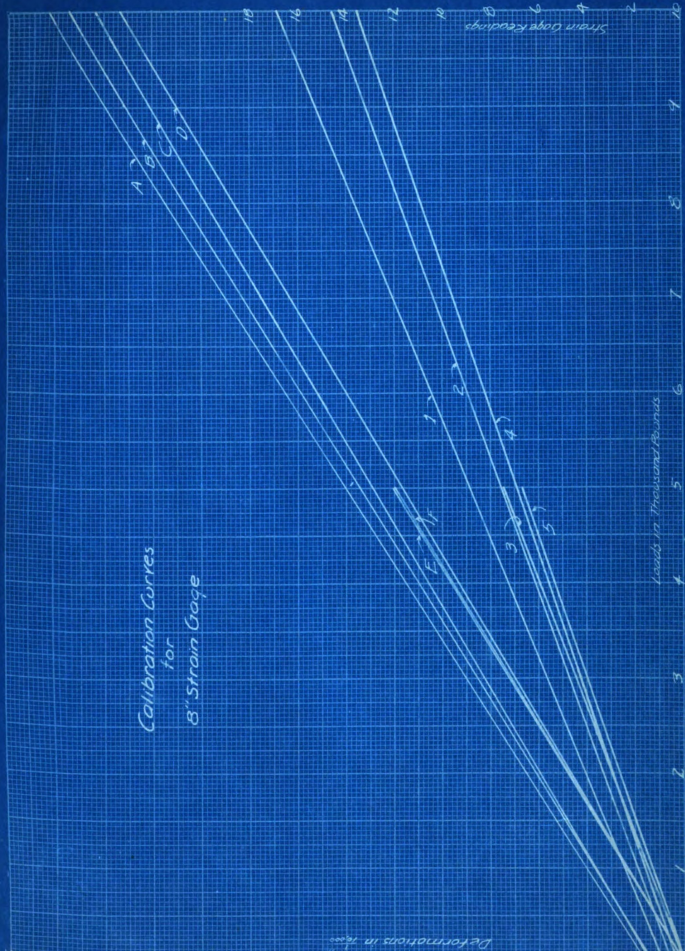
In the calibration of the gauge five tests were run on 3-3/4" bars. In the first two of these tests the load was applied in increments of 500# and the readings of the gauge taken. The bars were then accurately measured and the deformations computed. In the remaining three tests an extensometer was placed on the bar and the deformations were read with both the extensometer and the strain-gauge at intervals of 1000#. The deformation was also computed, using 30,000,000 as the modulus of elasticity of the steel.

Curves of the deformations and of the gauge readings were plotted for each of these tests. These curves are shown on page 42. Curves A, B and C show the deformations as determined by the extensometer readings corresponding to the strain-gauge readings shown by curves 1, 2 and 4 respectively. Curve D shows the computed deformations for the same gauge readings. Curves F and E show the computed deformations corresponding to the strain-gauge readings shown by curves 3 and 5 respectively.

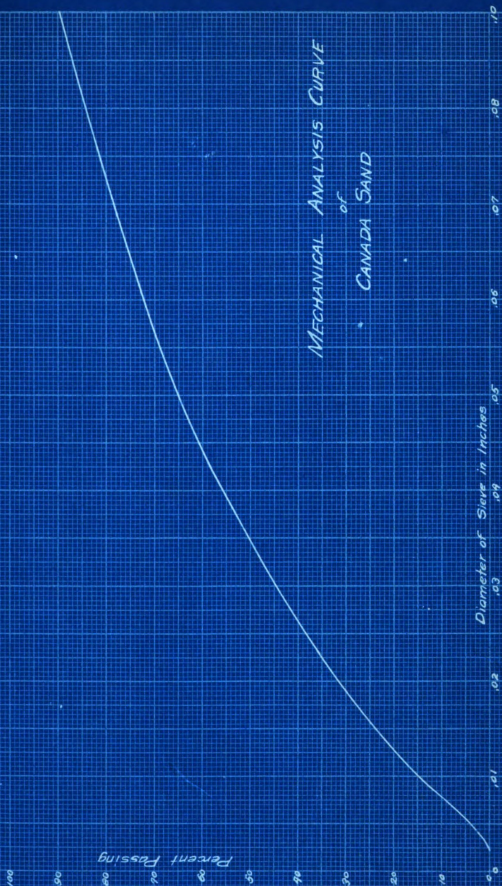
The value of one division of the gauge was computed from each of these curves and the average value was found to be 0.000334".

In all of the computations 1/3000" has been used as the value of one division of the strain-gauge.

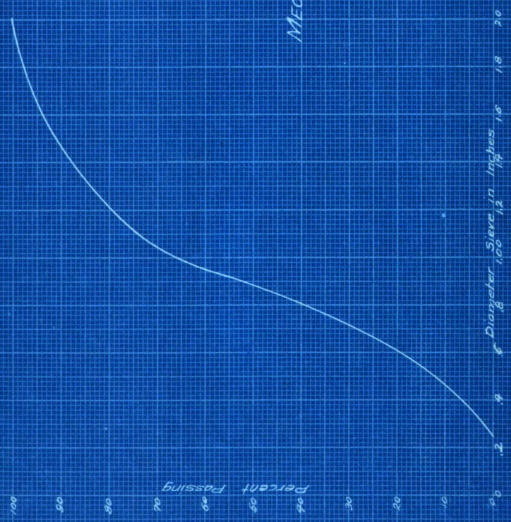
Calibration Curves
for
8" Strain Gage



MECHANICAL ANALYSIS CURVE
of
CANADA SAND



MECHANICAL ANALYSIS CURVE or RIVER GRAVEL



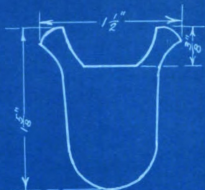


FIG. 3. CROSS-SECTION
OF BAR

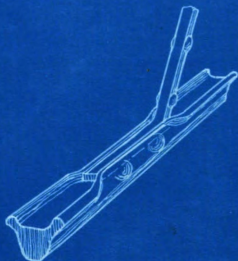
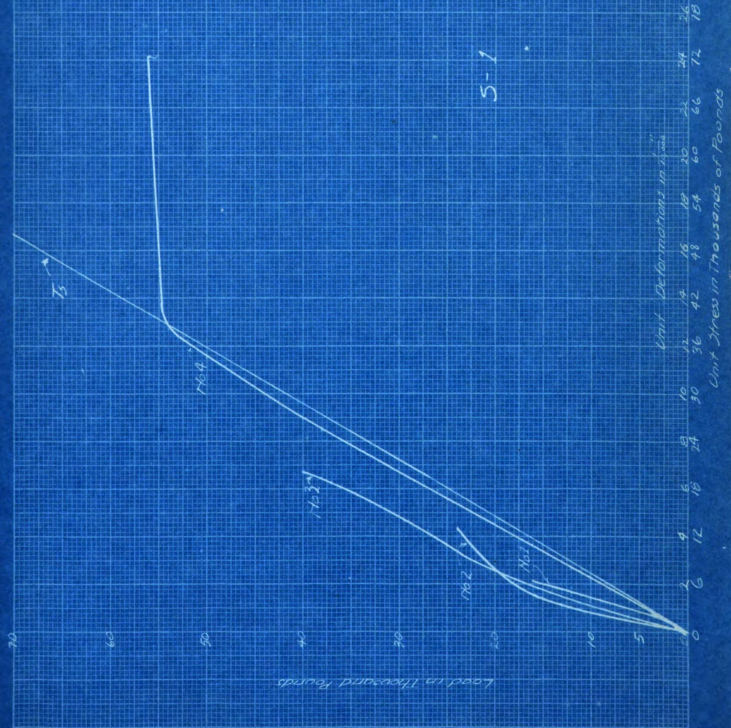
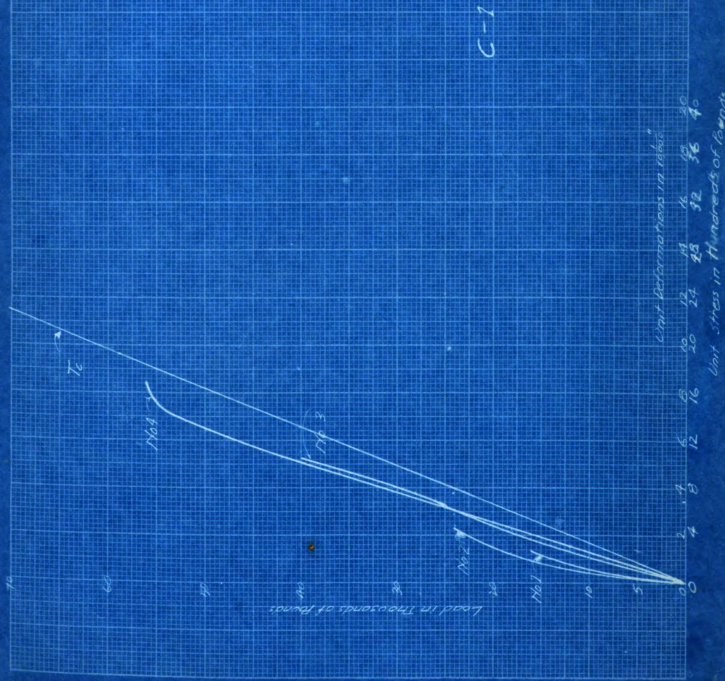


FIG. 4. SKETCH SHOWING METHOD
OF FASTENING AUXILIARY BARS





Shear in Thousands of Pounds

A-1

Unit Deformations in 1/1000

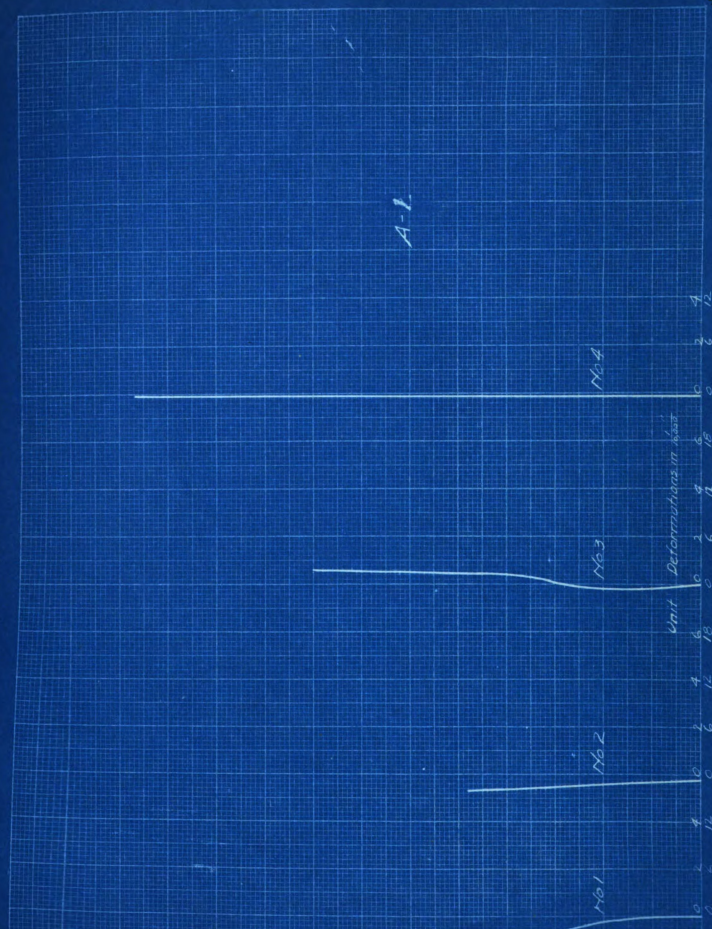
Unit Stress in Thousand Pounds

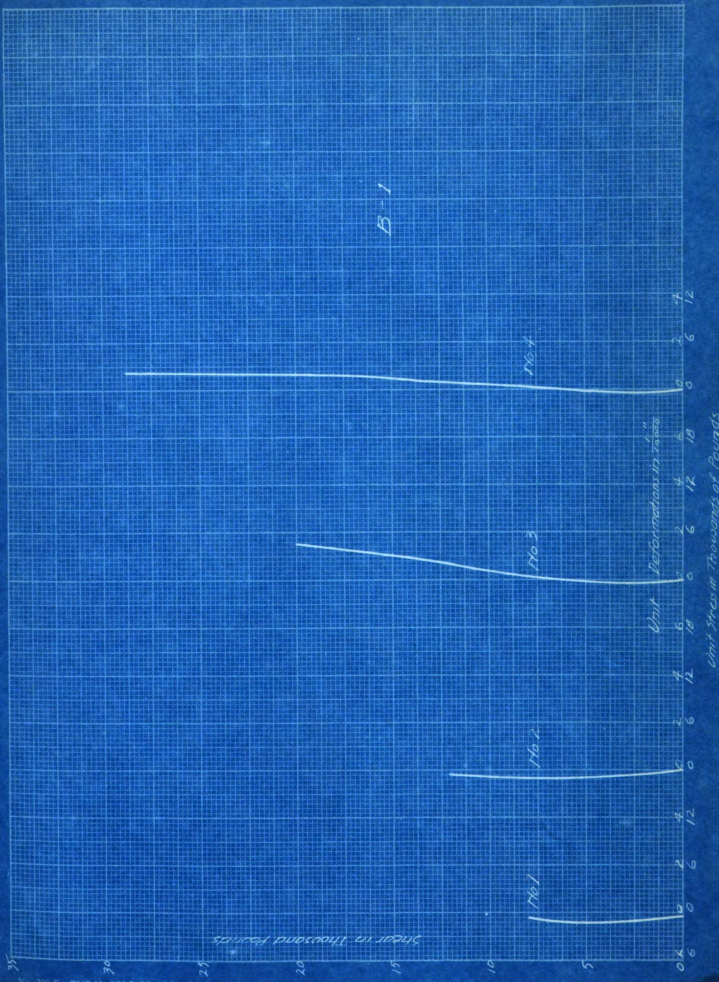
No 1

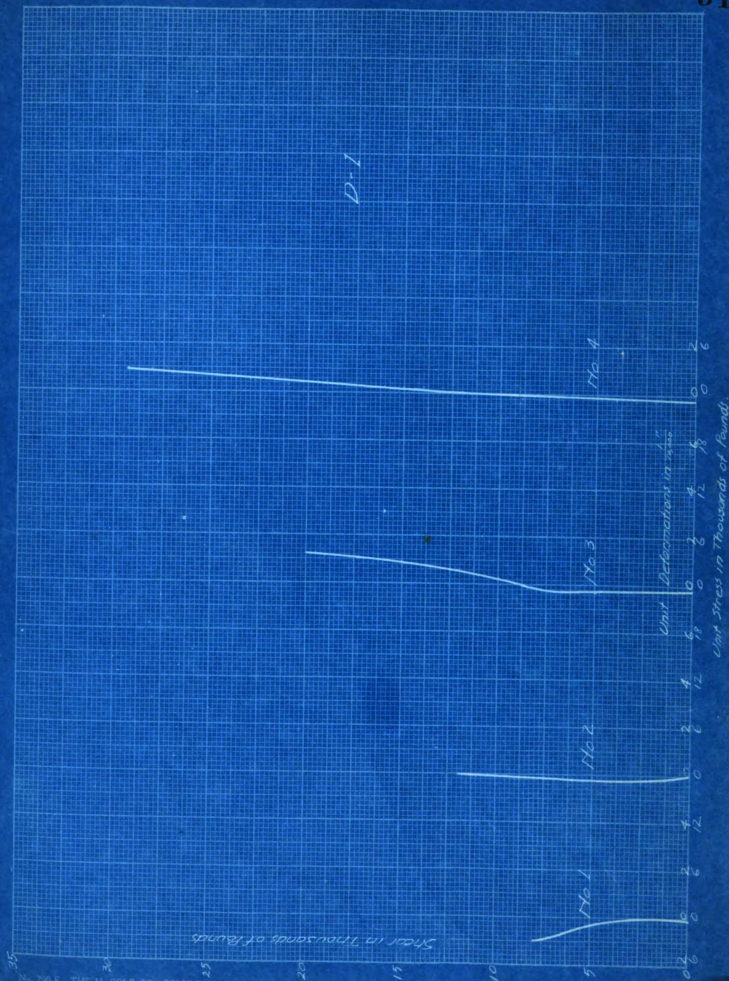
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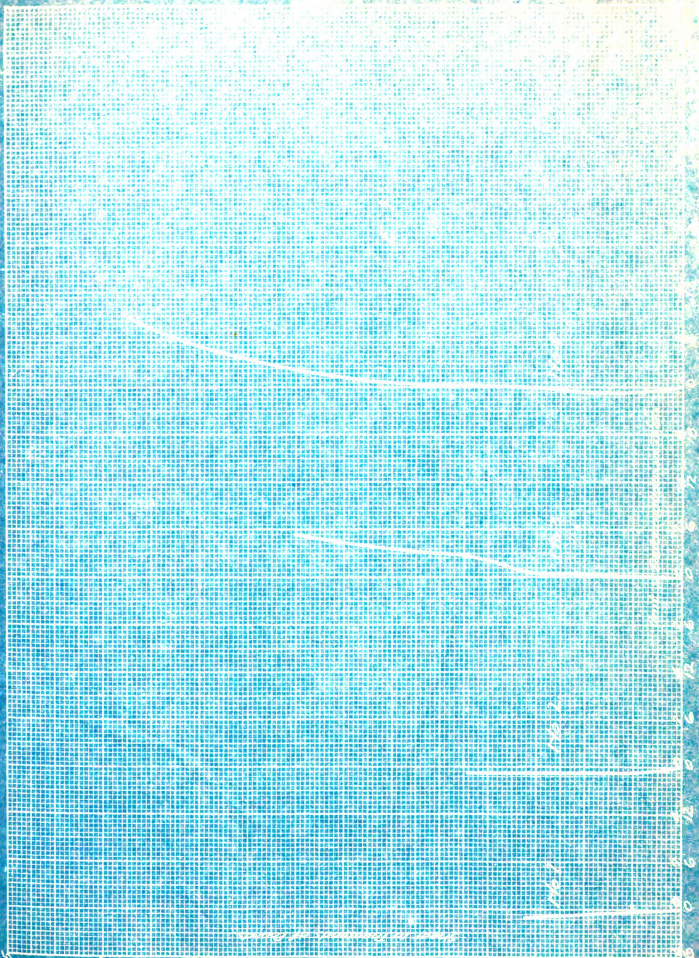
No 3

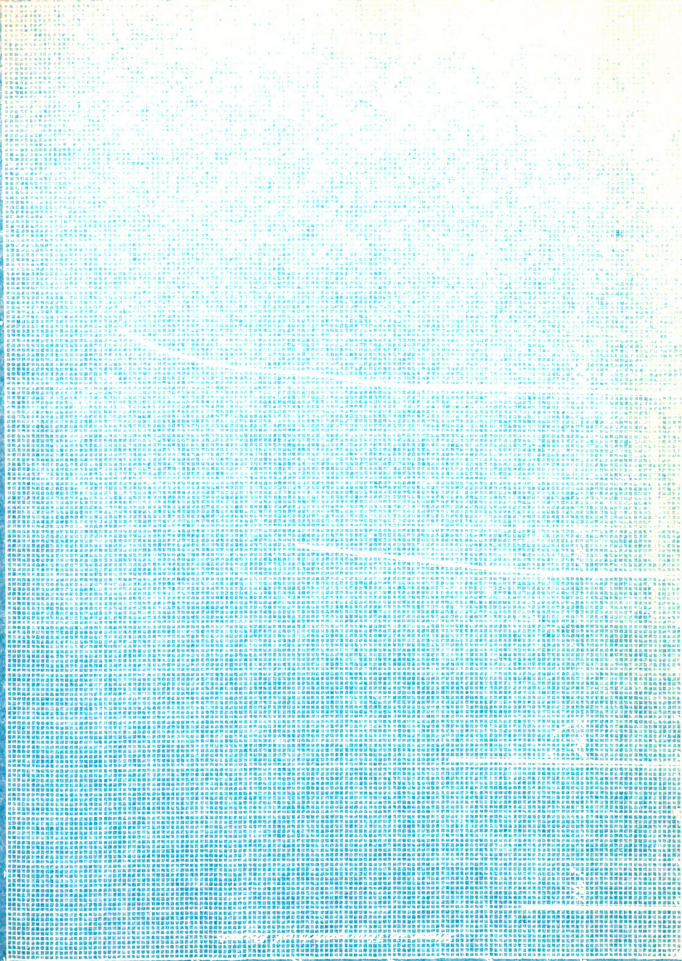
No 4











Stress in Thousands of Pounds

No. 1

No. 2

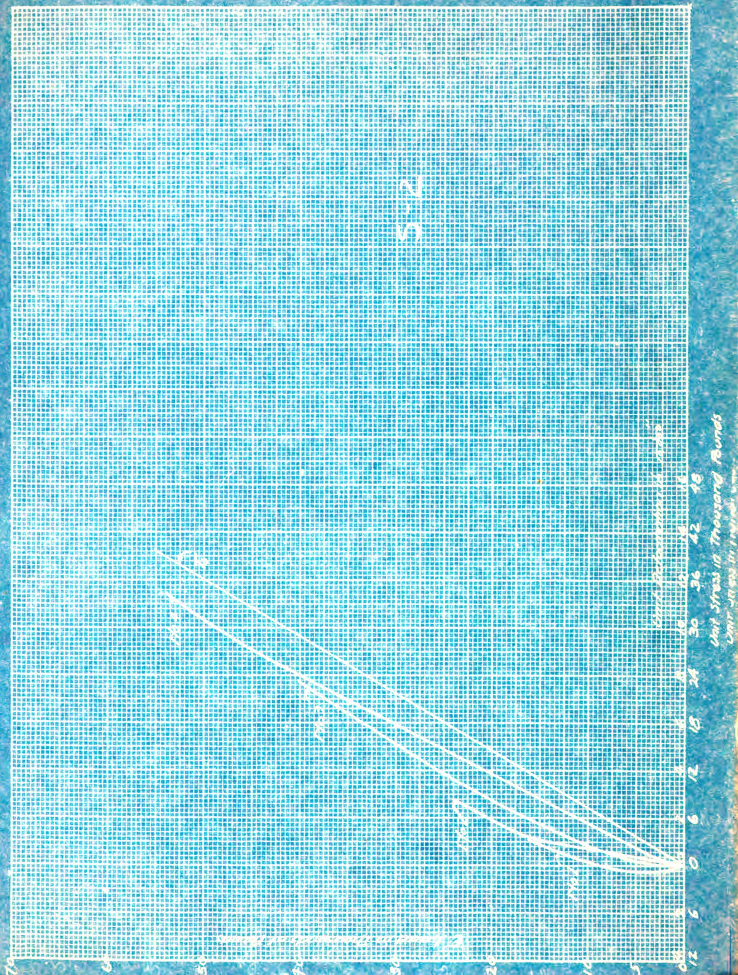
No. 3

No. 4

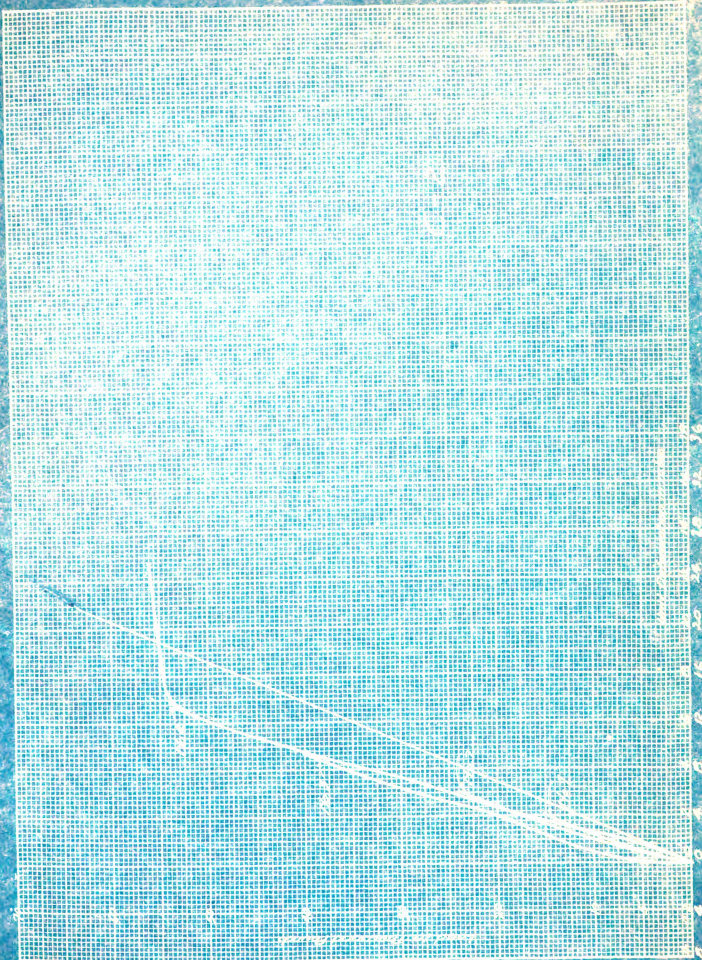
Strain Deformations in Inches

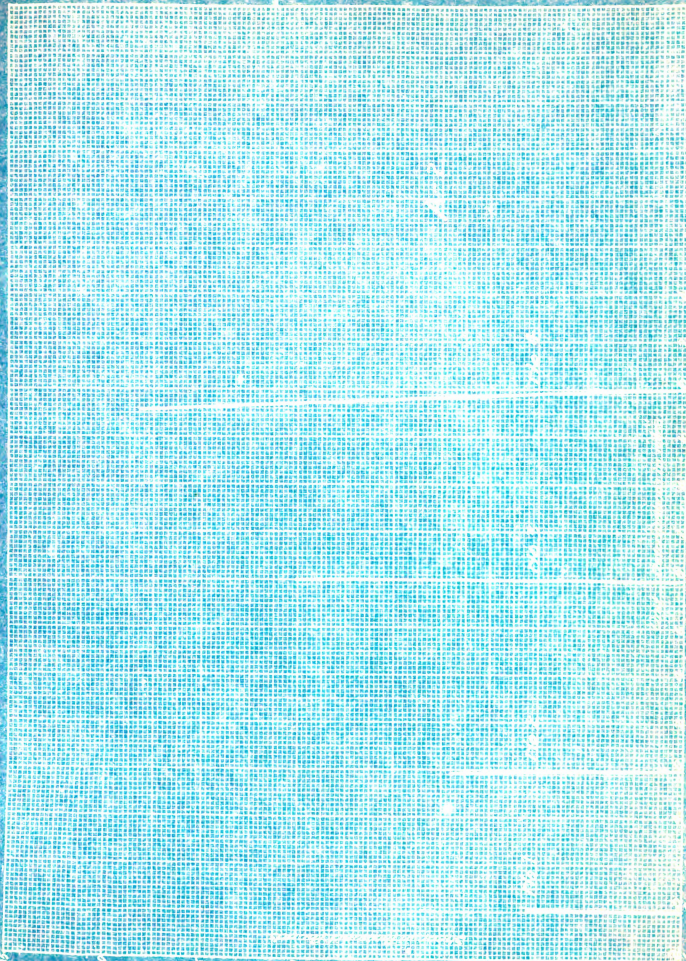
Unit Stress in Thousands of Pounds

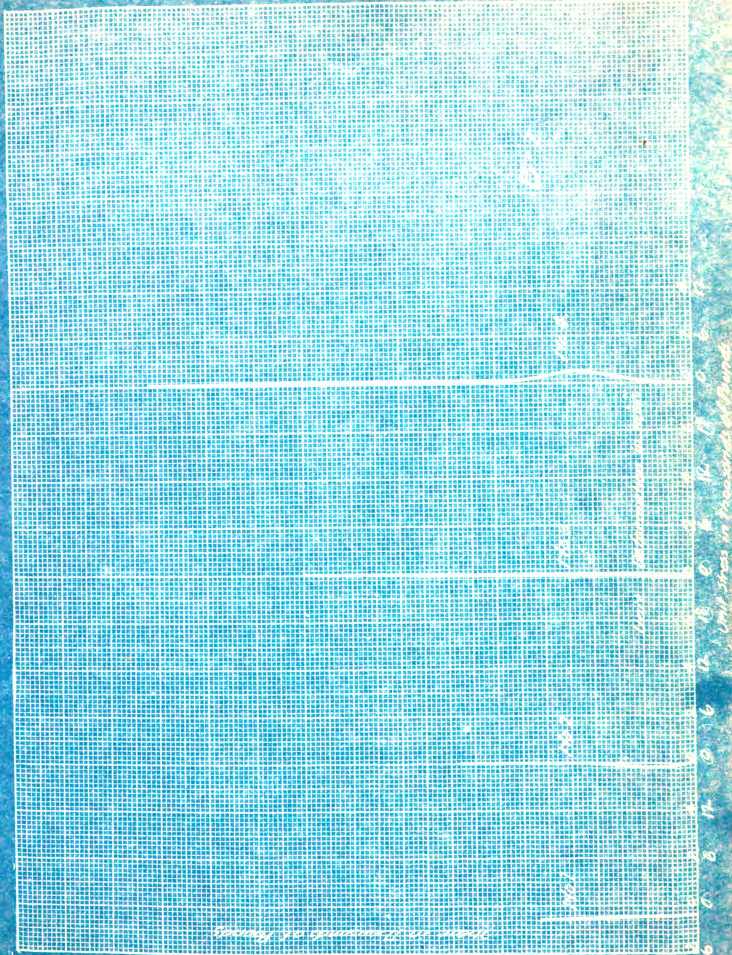
G-1

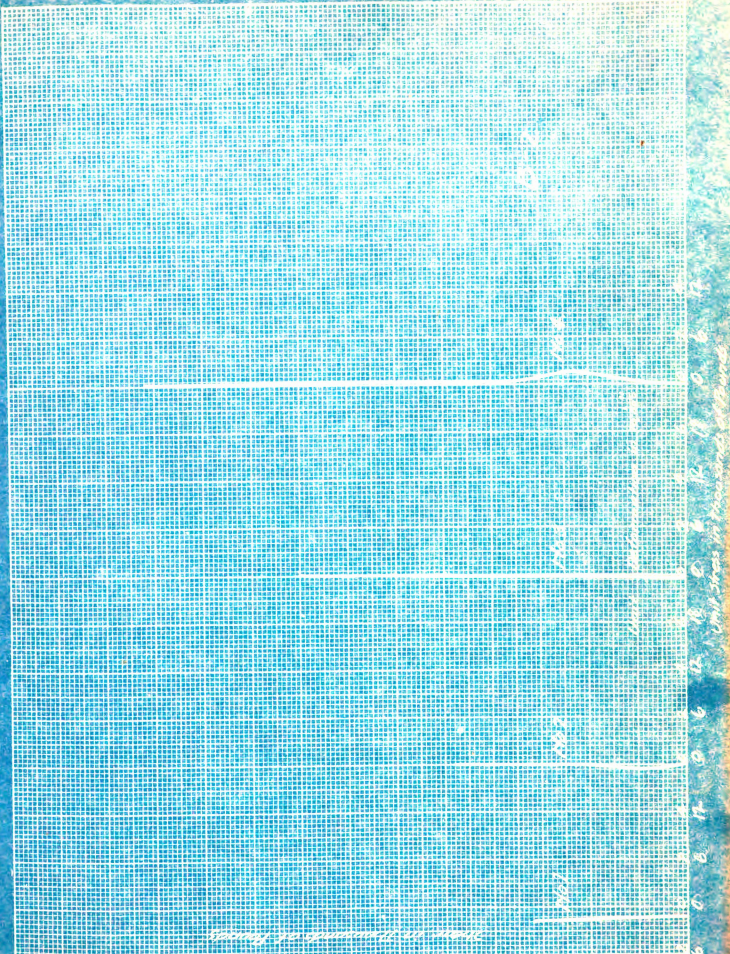


Unit Strain in Measured Bands
mm/mm in in









Shear in Thousands of Pounds

Unit Deformation in inches

Unit Stress in Tons per Square Inch

Stress in Thousands of Pounds

Unit Performance in $\frac{10^6}{\text{hr}}$

Unit Stress in Thousands of Pounds

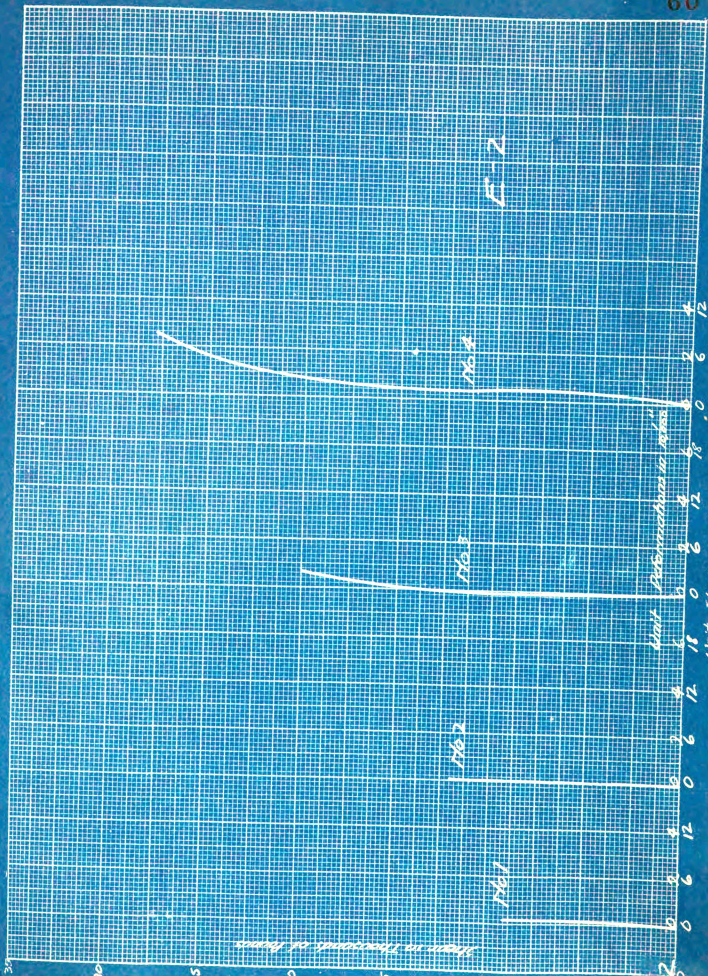
E-2

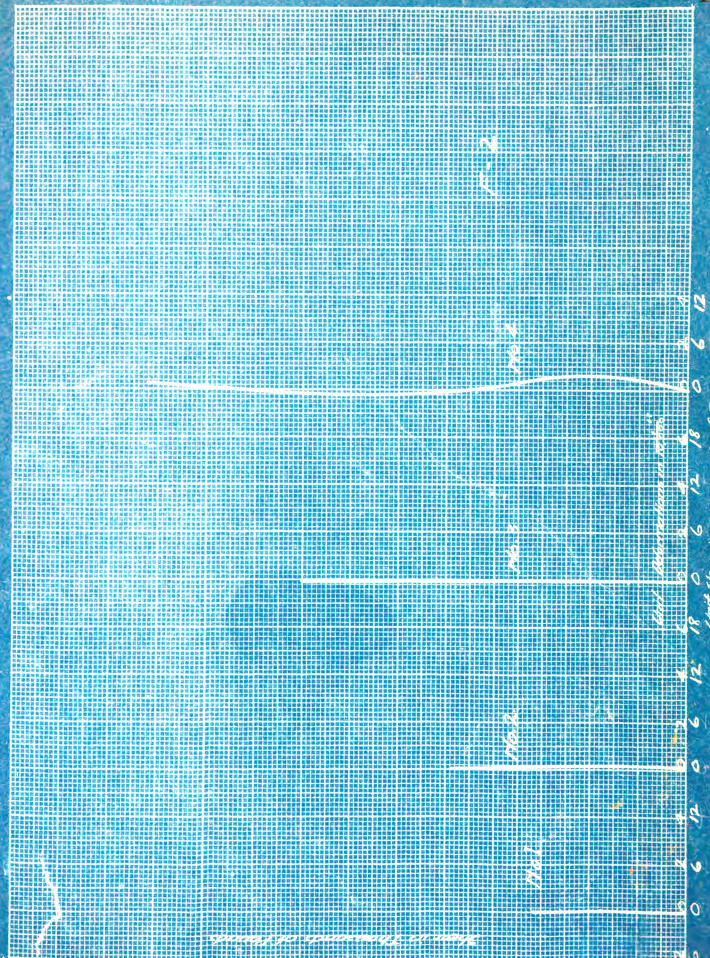
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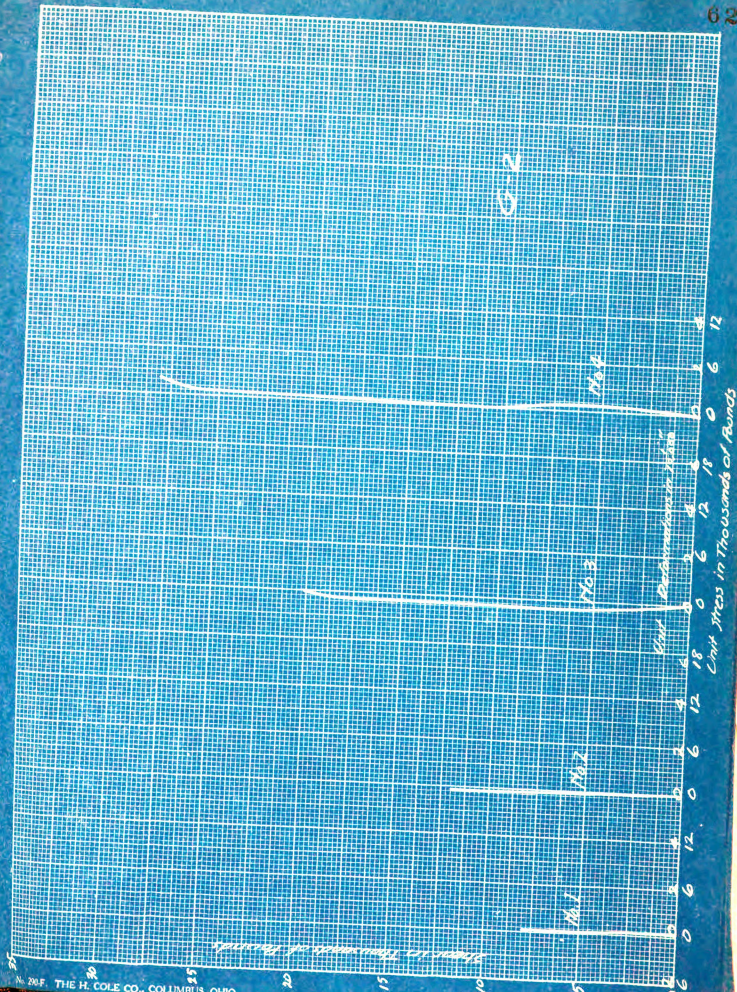
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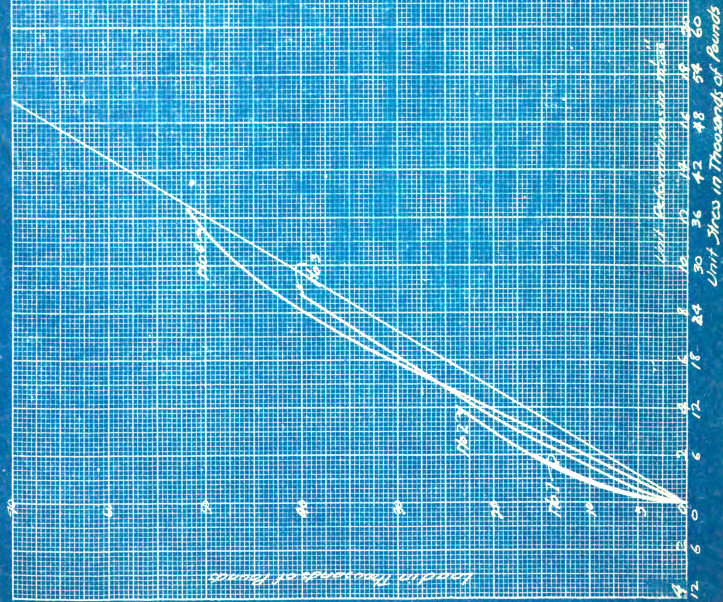
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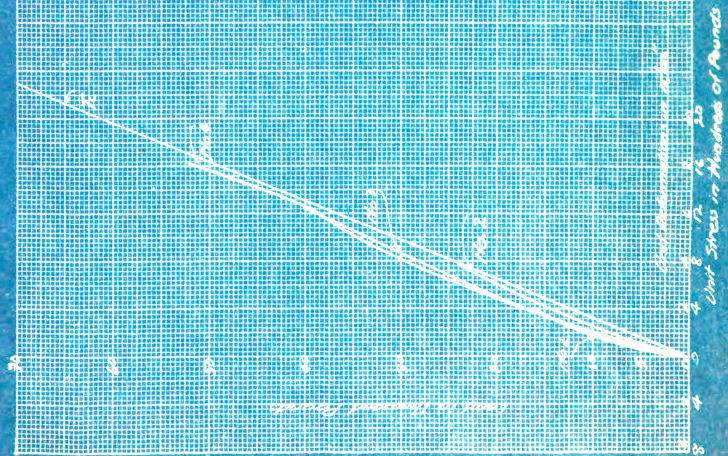
No. 1

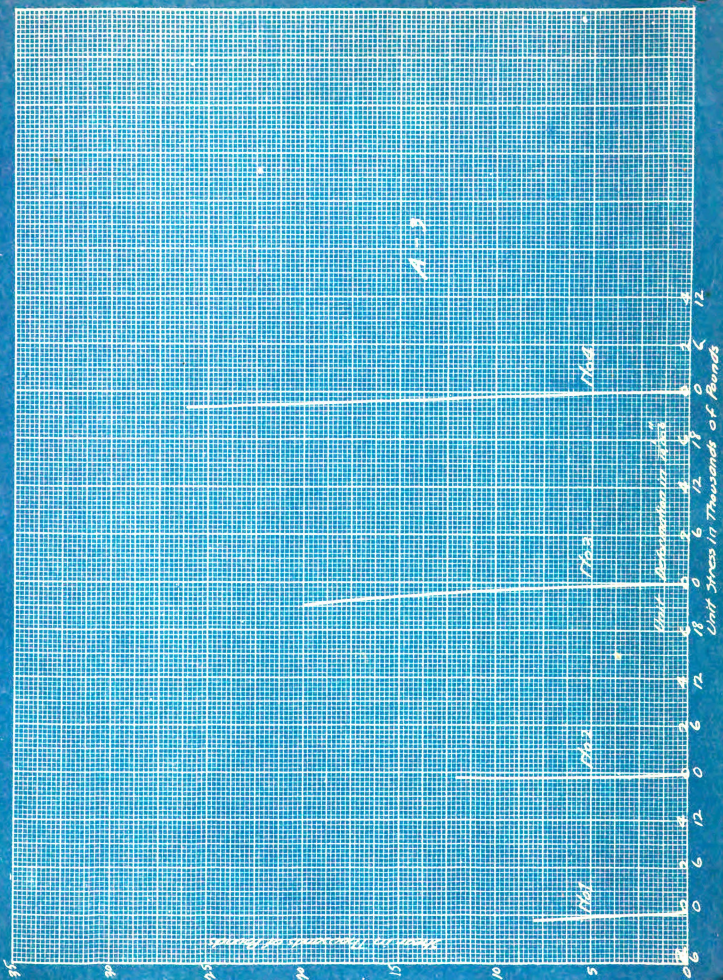


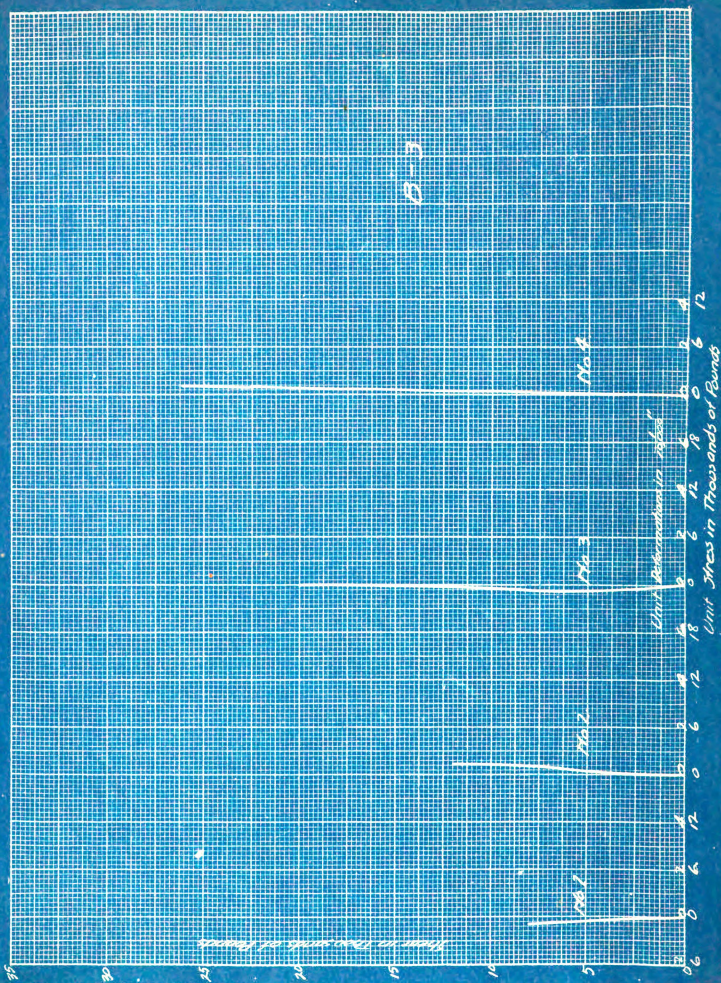












Stress in thousands of pounds

1000

2000

3000

4000

Unit Stress in 1000's

Unit Stress in 1000's

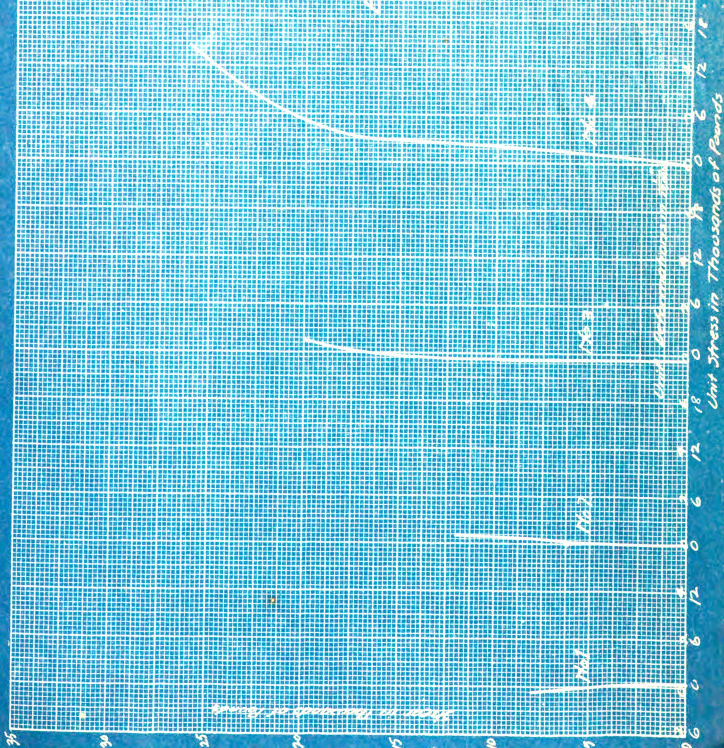
Unit Stress in 1000's

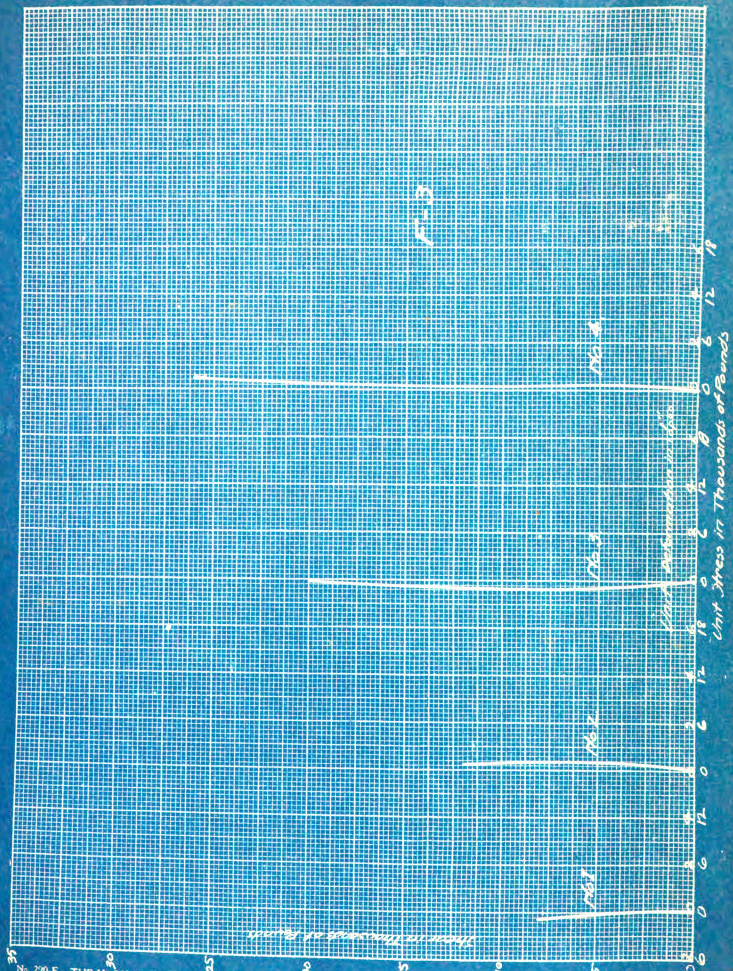
Unit Stress in 1000's

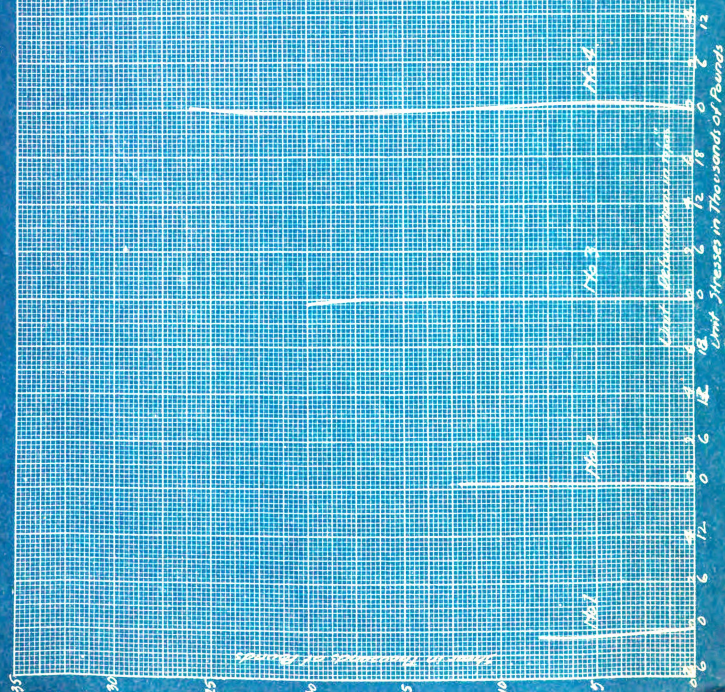
Unit Stress in 1000's

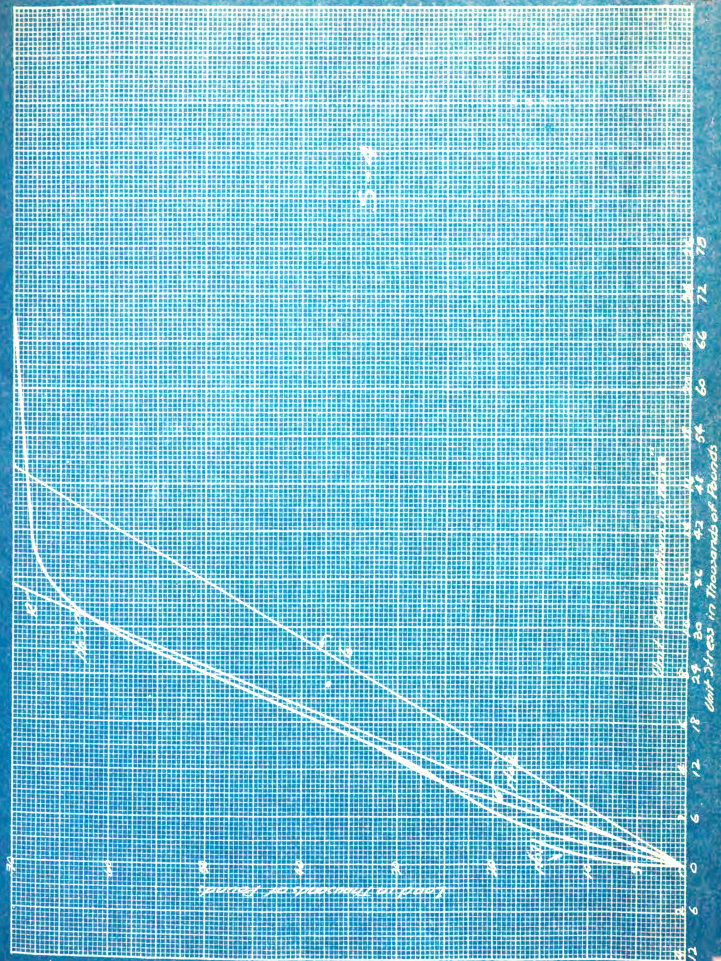
Unit Stress in 1000's

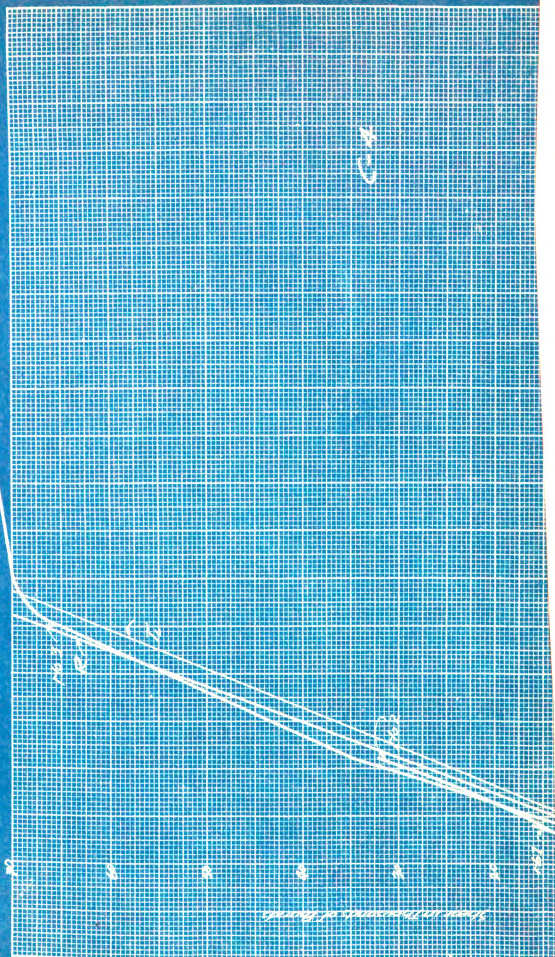
Unit Stress in 1000's

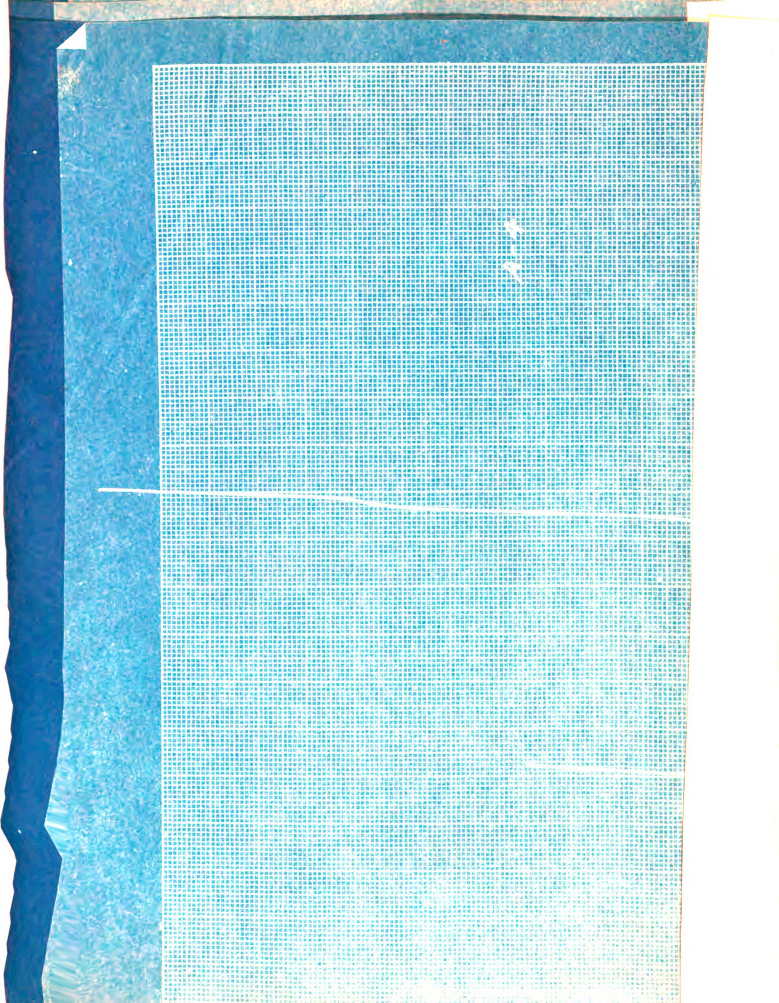


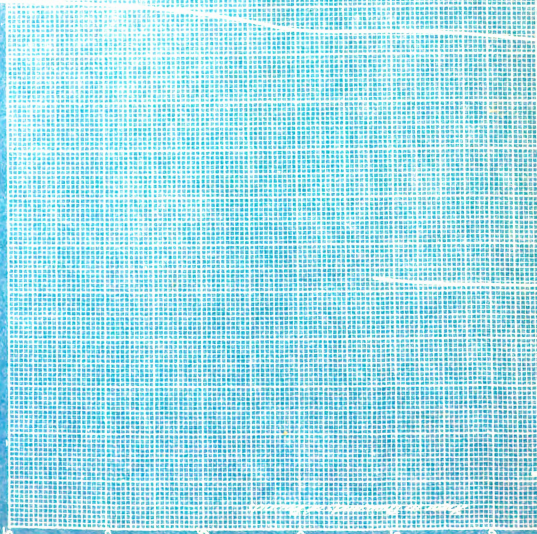
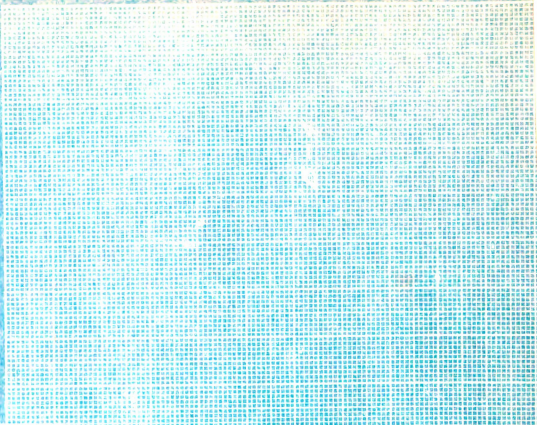








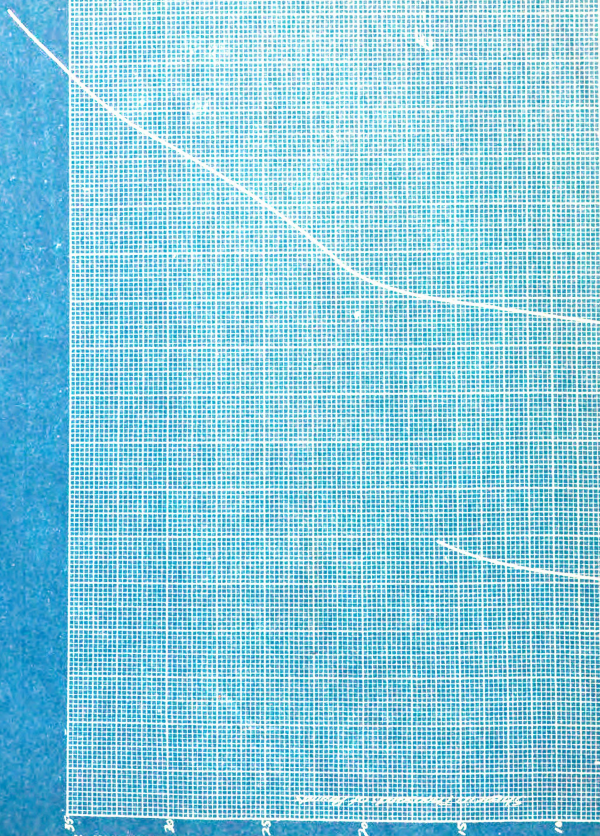


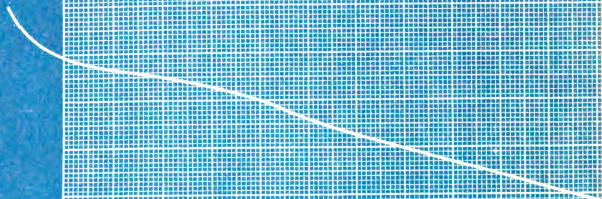


80

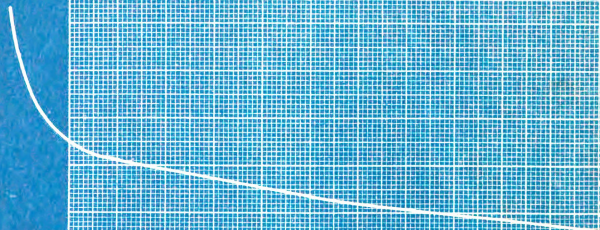


THEORY OF SPINNING AND WEAVING



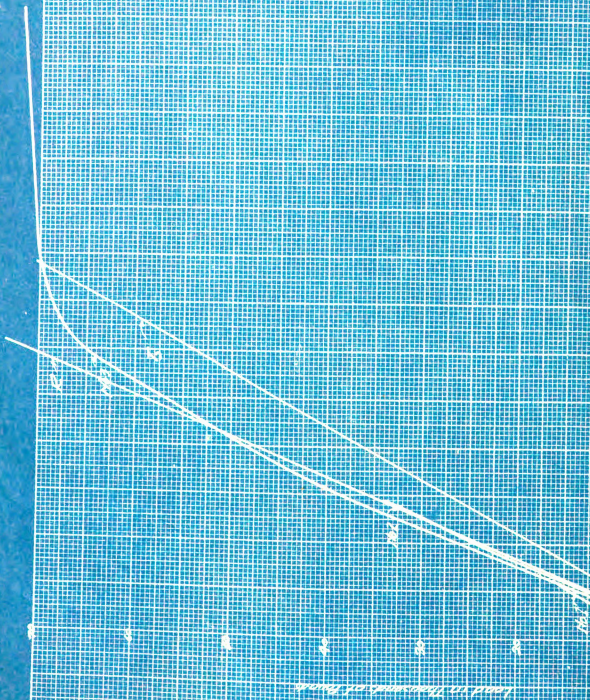


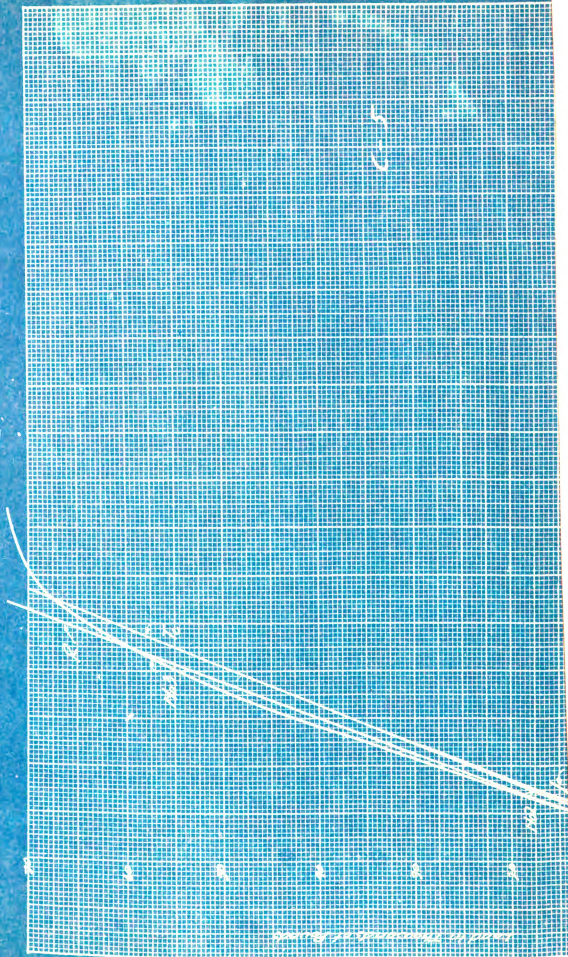
从以上分析可以看出，在“一带一路”倡议下，中国对东盟的贸易和投资合作呈现出快速增长的态势。未来，随着“一带一路”倡议的深入推进，中国对东盟的贸易和投资合作将继续保持强劲增长势头，为双方经济发展和区域繁荣做出更大贡献。



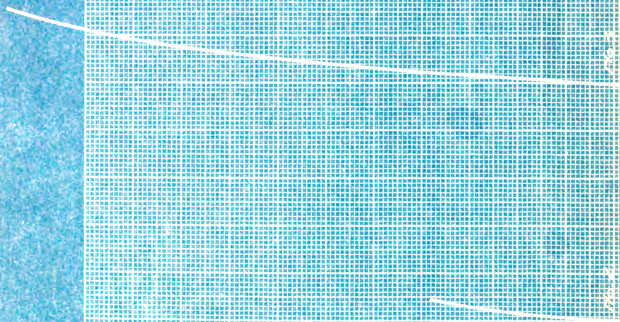
1.0

Approx. 100 degrees at 1000

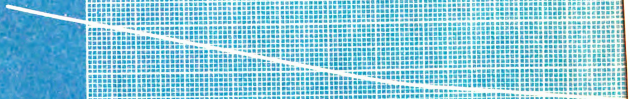




1000 is the number of points



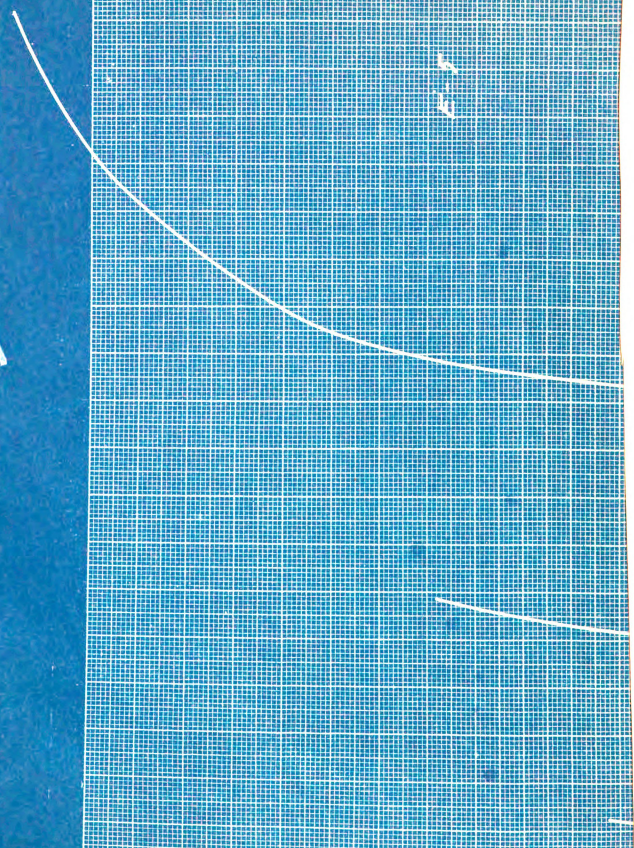


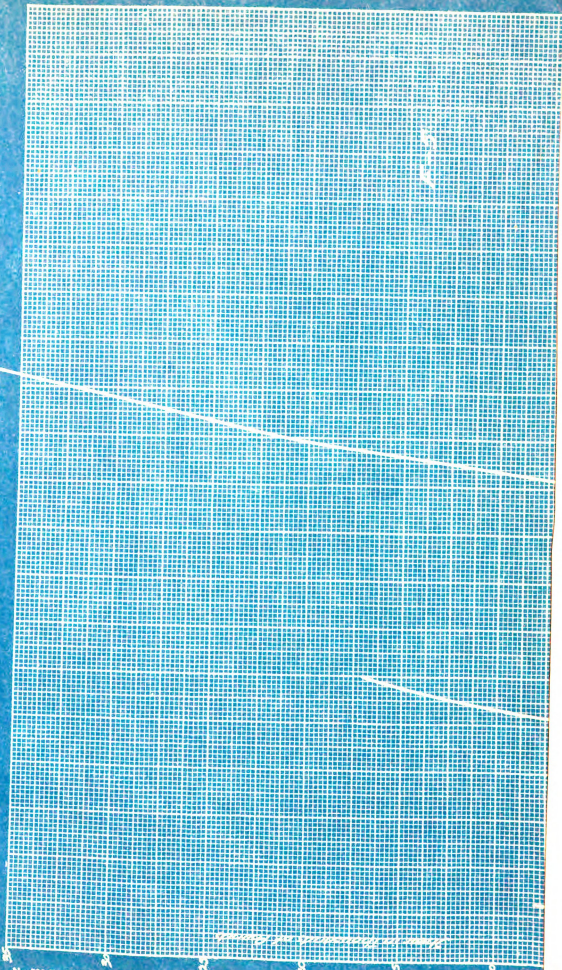


Graph in *Journal of Physics*

0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13 0.14 0.15 0.16 0.17 0.18 0.19 0.20 0.21 0.22 0.23 0.24 0.25 0.26 0.27 0.28 0.29 0.30 0.31 0.32 0.33 0.34 0.35 0.36 0.37 0.38 0.39 0.40 0.41 0.42 0.43 0.44 0.45 0.46 0.47 0.48 0.49 0.50 0.51 0.52 0.53 0.54 0.55 0.56 0.57 0.58 0.59 0.60 0.61 0.62 0.63 0.64 0.65 0.66 0.67 0.68 0.69 0.70 0.71 0.72 0.73 0.74 0.75 0.76 0.77 0.78 0.79 0.80 0.81 0.82 0.83 0.84 0.85 0.86 0.87 0.88 0.89 0.90 0.91 0.92 0.93 0.94 0.95 0.96 0.97 0.98 0.99 1.00

GRAPH OF STANDARDIZATION OF POTASSIUM

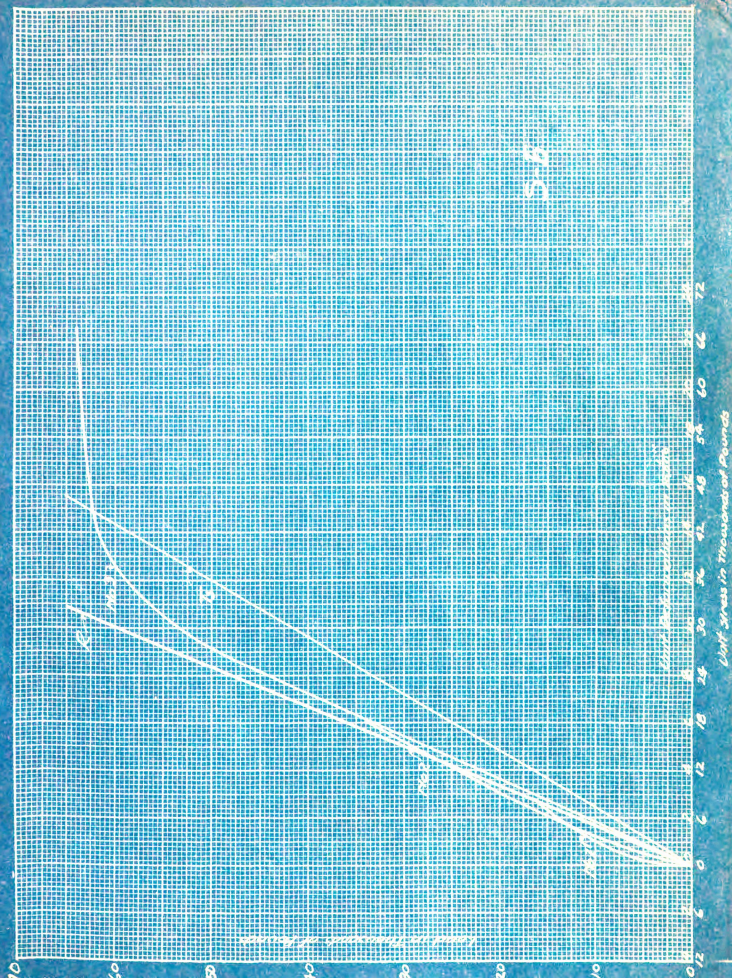


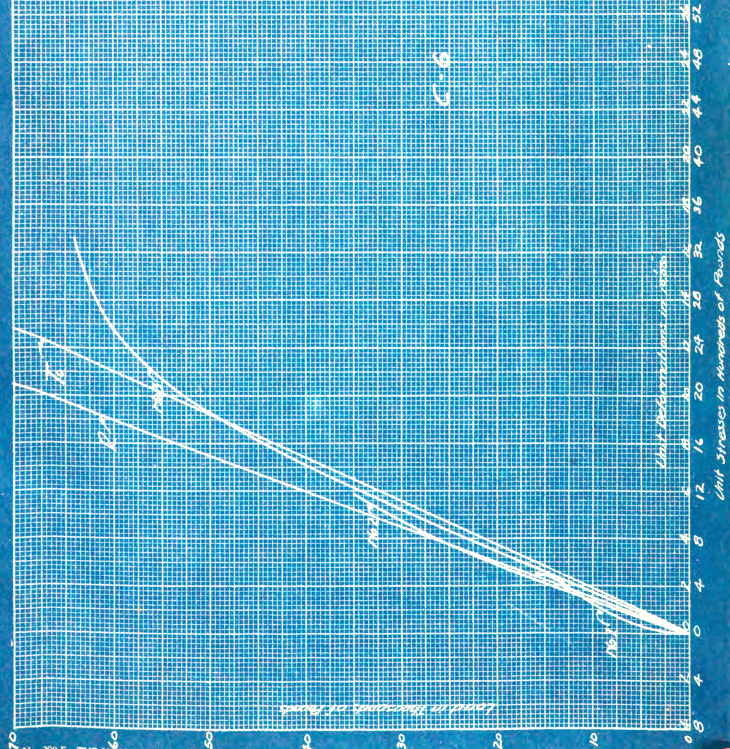


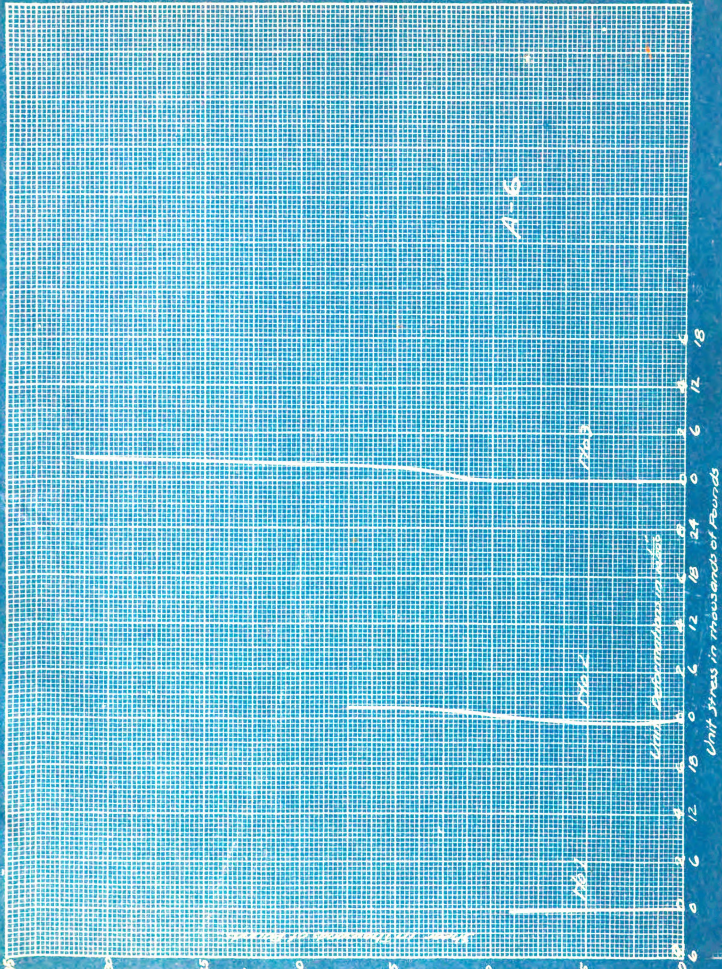
56

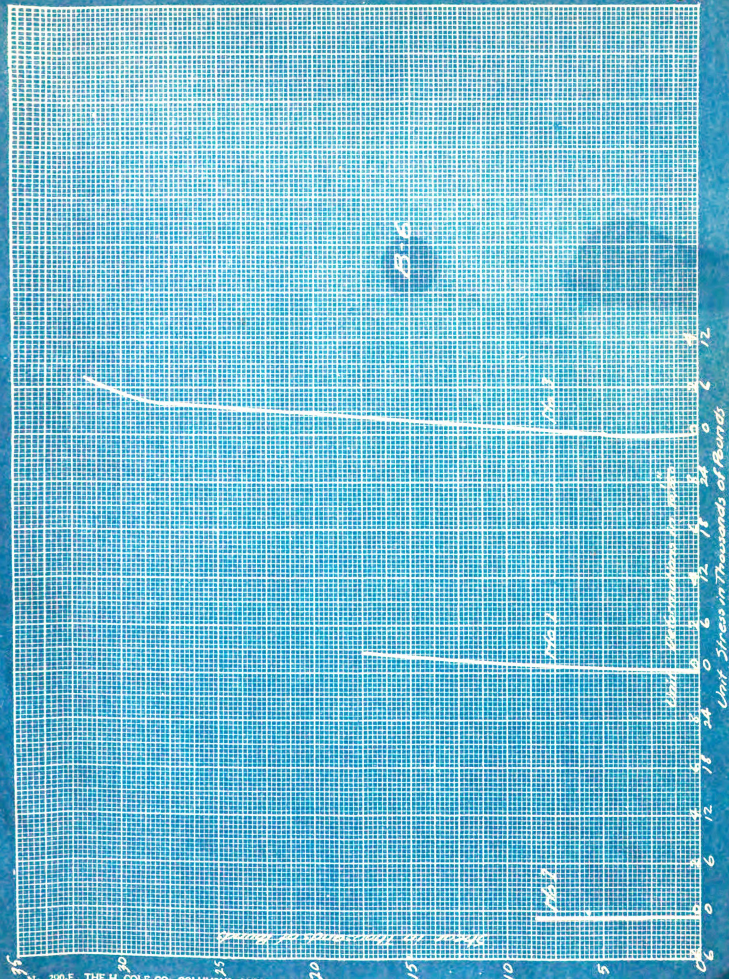
There is thousands of boards

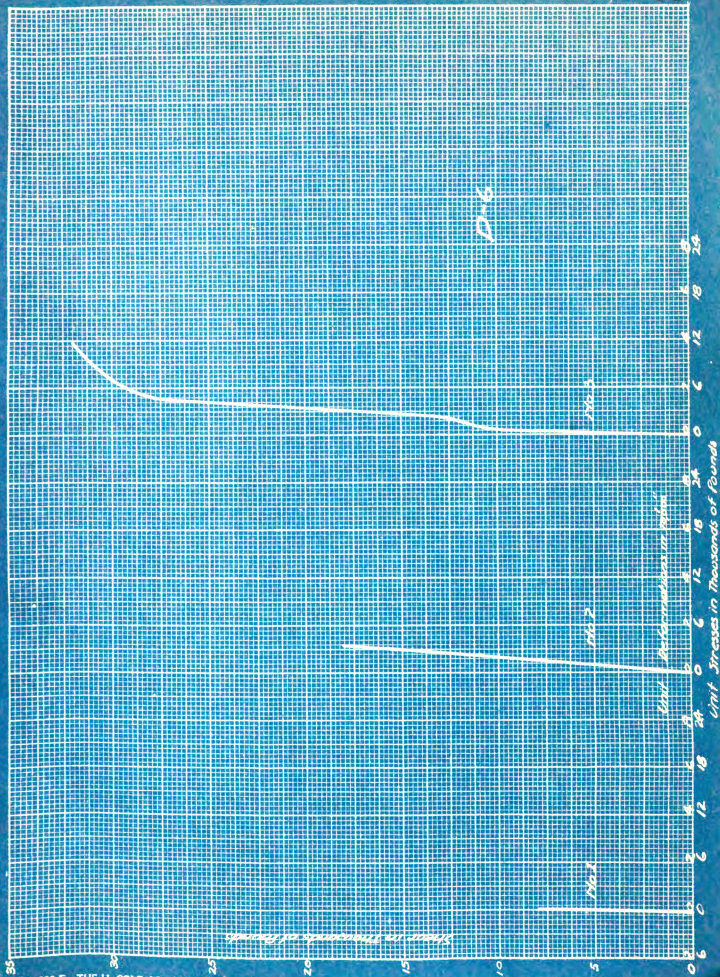
No. 290-F THE H. COLE CO. 3015 N.







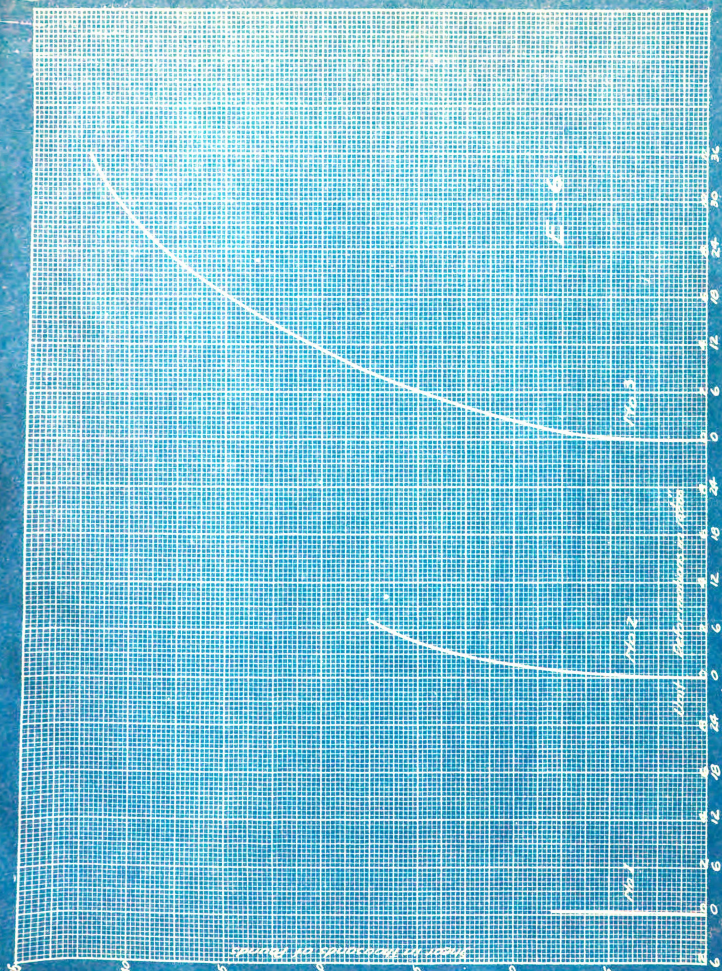


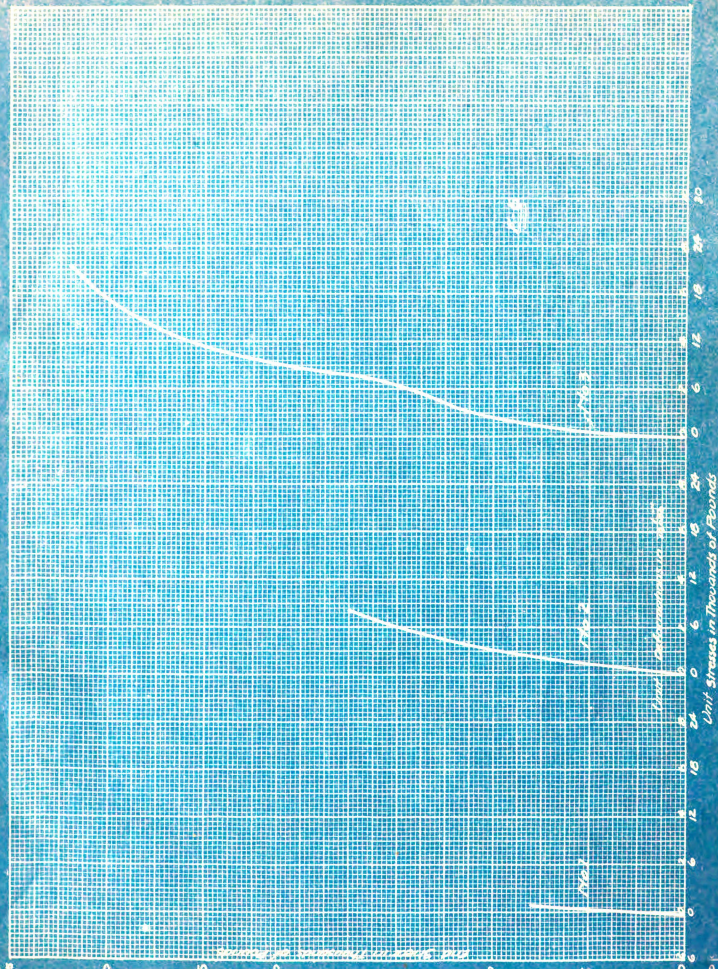


Stress in Thousands of Pounds

Unit deformations in mils

Unit Stresses in Thousands of Pounds





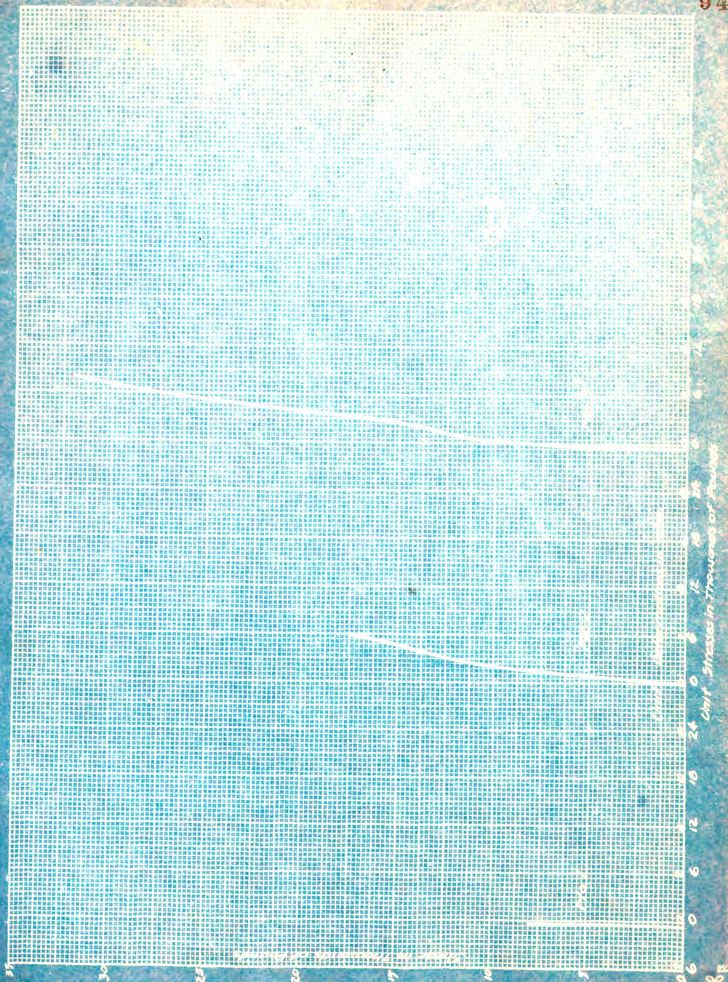


PLATE I

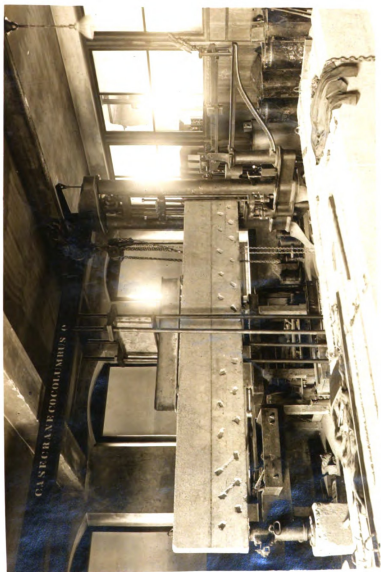


PLATE II



PLATE III



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