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CALIBRATION OF TESTING MACHINES UNDER DYNAMIC LOADING

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ABSTRACT

The errors of the indicated loads of testing machines used to determine the mechanical properties of engineering materials are usually determined for static loads. Testing machines are often used to load specimens continuously to failure at a given rate of loading. The additional errors, due to rate of loading, of six testing machines comprising four types widely used in this country were determined by means of a special elastic calibrating device for rates of loading up to 50,000 lb/min. The additional errors in the indicated loads of these machines, due to rate of loading, at rates currently used in testing, exceeded in several cases the tolerances specified for such testing machines. These errors, therefore, cannot in general be neglected when determining the rates of loading to be used in materials testing. The results of these tests, although they cannot be used to correct the indicated loads of other testing machines of the same types because of small inherent differences in the weighing systems and slight differences of adjustment, are useful in that they indicate the magnitude of the errors to be expected.

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I. INTRODUCTION

The errors of the indicated loads of testing machines used to determine the mechanical properties of engineering materials are usually determined by methods of calibration involving the use of dead weights, standardized proving levers, or elastic calibration devices. These methods of calibration are included in the methods of calibration specified by the American Society for Testing Materials [1]. Each of these methods requires a constant or slowly increasing test load, while the calibrating device and the testing machine are read simultaneously. On the other hand, in materials testing, specimens are often loaded continuously to failure at a given rate of loading. The rate of loading for cement mortar cubes, for instance, may be as great as 6,000 lb/in.^{2}/min (24,000 lb/min for the standard cube)[2]. It is therefore important to know the magnitude of the errors of testing machines at the rates of loading used in testing. The additional errors due to rate of loading were determined for rates of loading up to 50,000 lb/min for six testing machines by means of a special elastic calibrating device. The six testing machines included one beam-and-poise, screw-driven machine; two pendulum, hydraulic machines; one spring, hydraulic machine; and two fluid-support, Bourdon-tube, hydraulic machines.

II. DESCRIPTION OF TESTING MACHINES

1. MACHINE *A*, BEAM AND POISE, SCREW-DRIVEN

The 50,000-lb capacity beam-and-poise, screw-driven machine, designated as machine *A*, is shown in figure 1. The load is applied to the specimen by the movable platen, *M*, which is moved by three screws. These screws are driven through gearing by an electric motor. The other platen, *N*, is supported upon a system of levers having knife-edge bearings. The lever system includes a graduated weigh beam, *O*, upon which a poise is moved manually, through gearing, by means of the hand wheel, *P*. When the beam is balanced, the magnitude of the load is indicated by the position of the poise on the beam. A vernier dial, graduated into 10-lb divisions, is provided to indicate fractional parts of the beam divisions.

Four different speeds of the movable platen, *M*, are obtainable by different gear combinations for a given motor speed. The motor speed can be controlled by means of multiple-step electrical resistances, *R*, so that the speed of the movable platen is almost continuously variable.

2. MACHINE *B*, PENDULUM, HYDRAULIC

The 50,000-lb capacity pendulum, hydraulic machine, designated as machine *B*, is shown in figure 2. The load is applied to the specimen by the movable platen, *M*, which is moved by a hydraulic jack which has no packing. This jack is connected hydraulically to two small jacks, the cylinders of which are rotated continuously to reduce friction. The pistons of the small jacks are connected mechanically to weighted pendulums by means of flexible steel straps. The force

[1] Am. Soc. Testing Materials Standards I, 849–860 (1936).
[2] Am. Soc. Testing Materials Tentative Standards, 393–398 (1936).

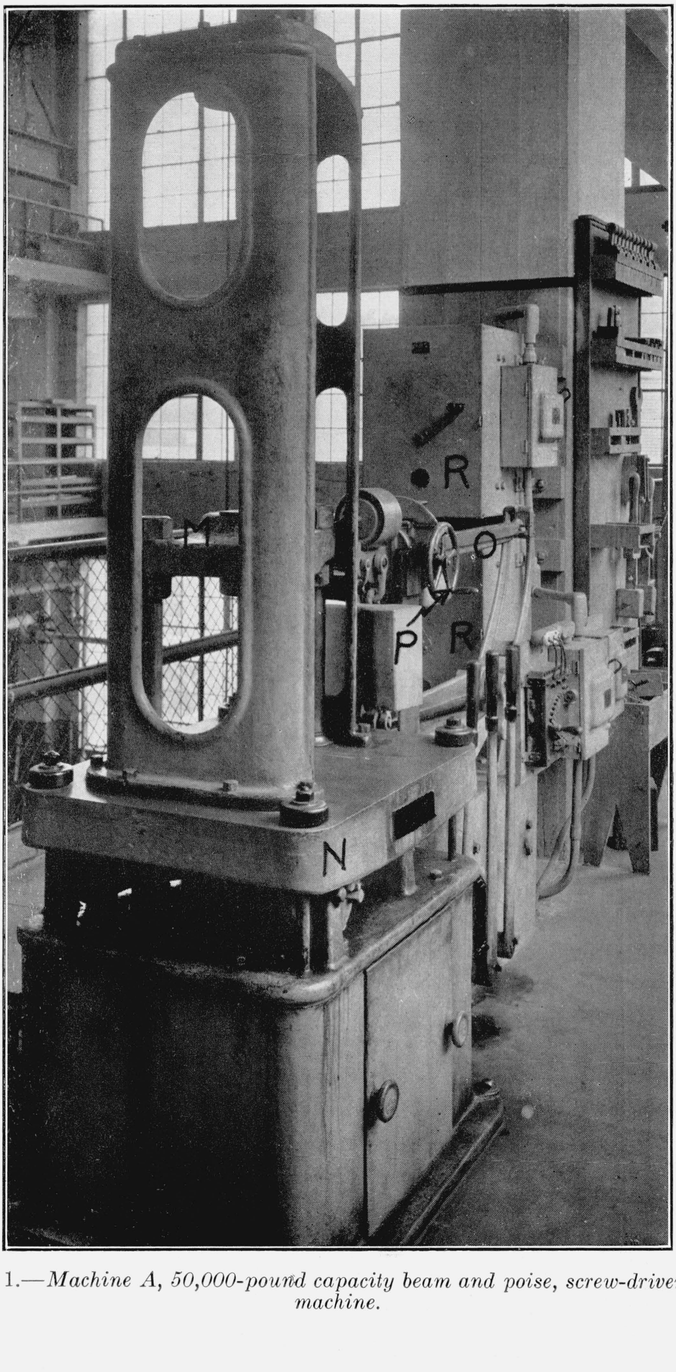

FIGURE 1.—*Machine A, 50,000-pound capacity beam and poise, screw-driven testing machine.*

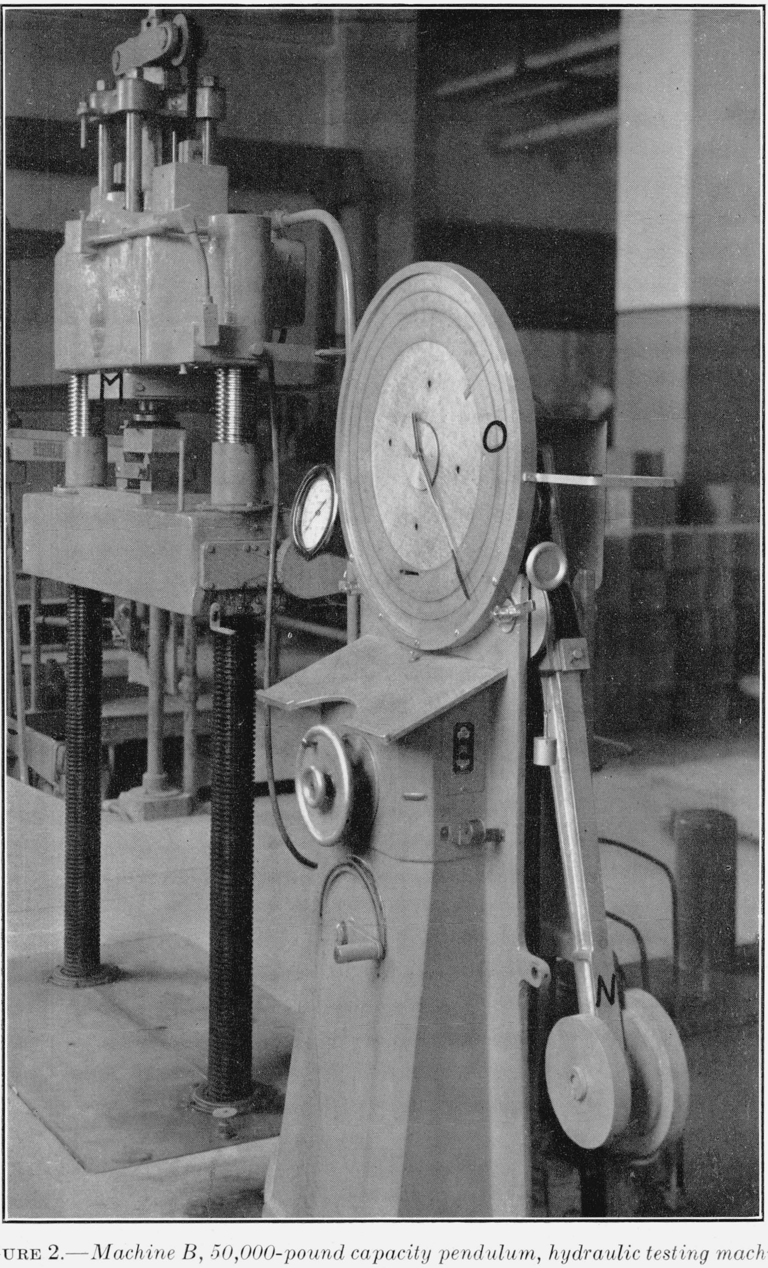

FIGURE 2.—*Machine B, 50,000-pound capacity pendulum, hydraulic testing machine.*

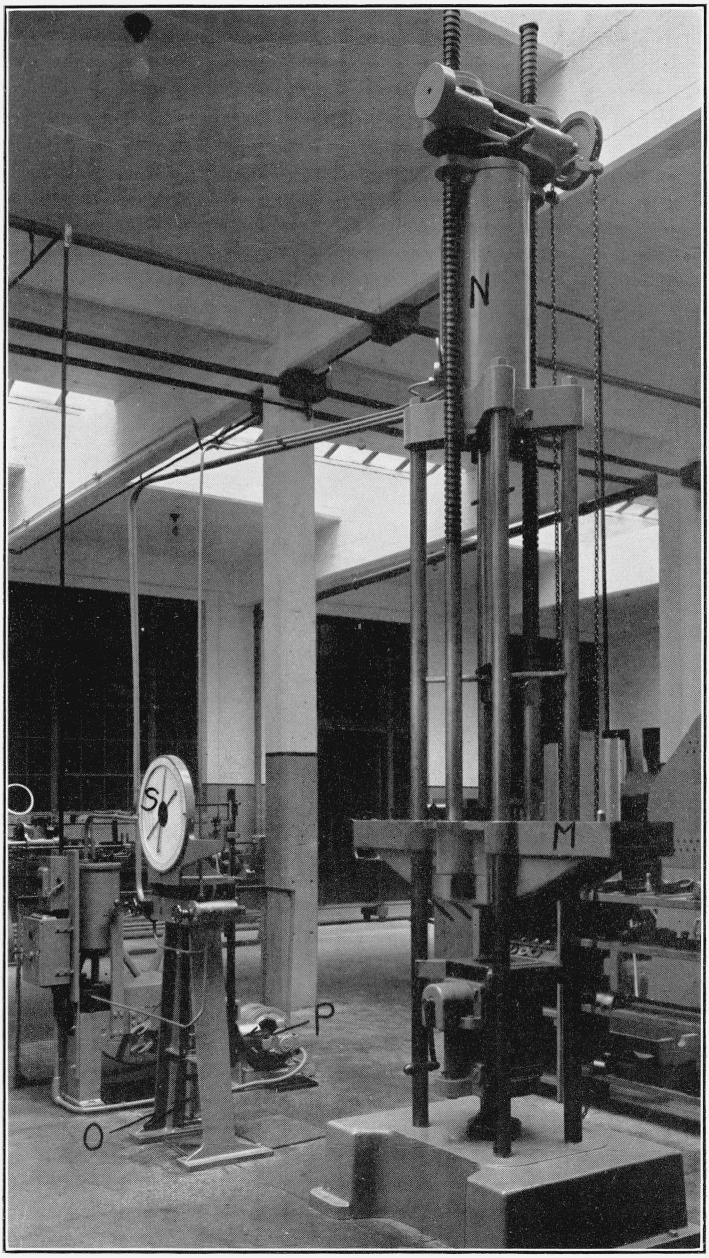

FIGURE 3.—*Machine C, 100,000-pound capacity pendulum, hydraulic testing machine.*

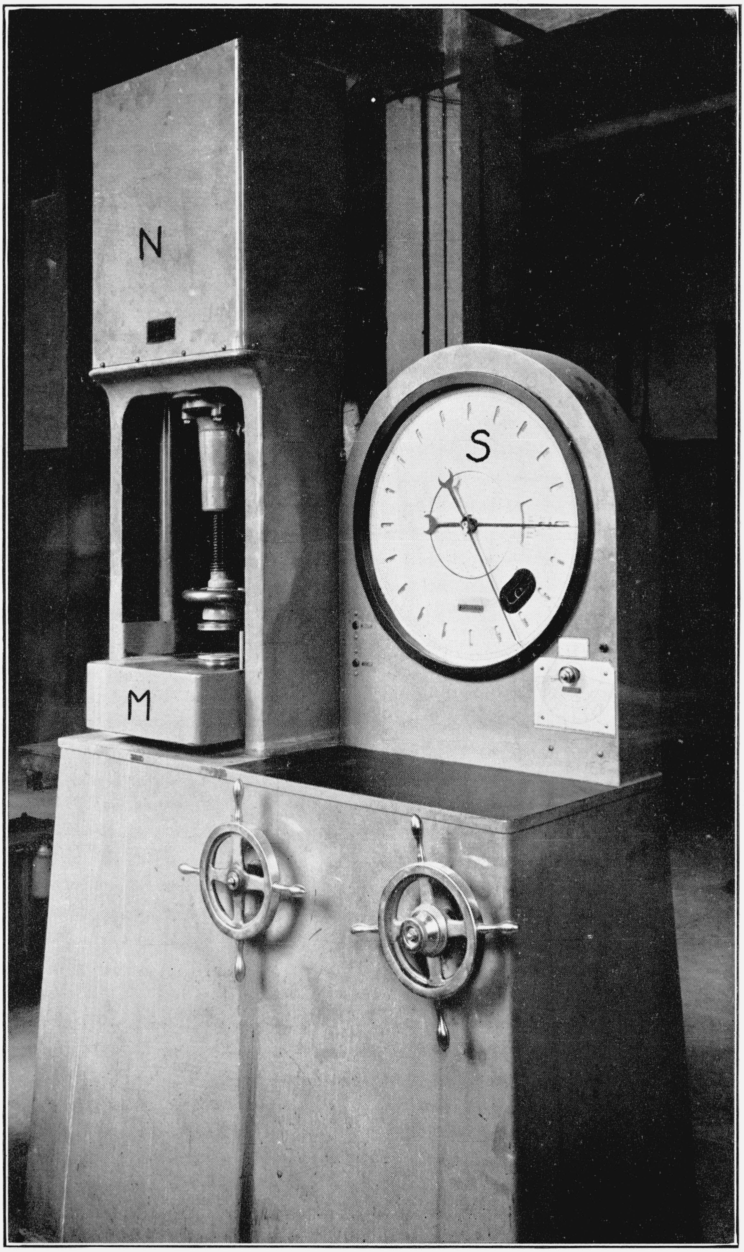

FIGURE 4.—*Machine D, 50,000-pound capacity spring, hydraulic testing machine.*

exerted by these pistons deflects the pendulums from their vertical positions. One of the pendulums, *N*, is shown in figure 2. Only one pendulum is used at a time. The pendulums are connected mechanically to a pointer which moves around a series of concentric graduated circular scales, *O*. The magnitude of the load is automatically indicated by the position of the pointer. A maximum pointer is provided to indicate the maximum load applied by the machine during a test.

This machine has scale ranges of 0 to 50,000 lb, 0 to 25,000 lb, 0 to 10,000 lb, and 0 to 5,000 lb. Tests were made using the 0- to 50,000-lb and the 0- to 10,000-lb scale ranges. These scale ranges are graduated into 50-lb and 10-lb divisions, respectively.

3. MACHINE *C*, PENDULUM, HYDRAULIC

The 100,000-lb capacity pendulum, hydraulic machine, designated as machine *C*, is shown in figure 3. The load is applied to the specimen by the movable platen, *M*, which is moved by a hydraulic jack, *N*, which has no packing. This jack is connected hydraulically to a small jack, *O*, the piston of which is rotated continuously to reduce friction. The piston of this small jack is connected mechanically to the weighted pendulum, *P*. The force exerted by the piston deflects the pendulum from its vertical position. The pendulum is connected mechanically to a pointer which moves around a graduated circular scale, *S*. The magnitude of the load is automatically indicated by the position of the pointer. A maximum pointer is provided to indicate the maximum load applied by the machine during a test.

This machine has scale ranges of 0 to 100,000 lb, 0 to 50,000 lb, 0 to 20,000 lb, and 0 to 10,000 lb. Tests were made using the 0- to 100,000-lb, 0- to 50,000-lb, and 0- to 10,000-lb scale ranges. These scale ranges are graduated into 100-lb, 50-lb, and 10-lb divisions, respectively.

4. MACHINE *D*, SPRING, HYDRAULIC

The 50,000-lb capacity spring, hydraulic machine, designated as machine *D*, is shown in figure 4. The load is applied to the specimen by the movable platen, *M*, which is moved by a hydraulic jack located inside the cover, *N*. This jack has no packing and its cylinder is rotated continuously to reduce friction. The loading jack is connected hydraulically to a small jack, the cylinder of which is rotated continuously to reduce friction. The piston of this small jack is connected mechanically to a pair of springs. The deflection of these springs is indicated by a pointer which moves around a graduated circular scale, *S*. The magnitude of the load is automatically indicated by the position of the pointer. A maximum pointer is provided to indicate the maximum load applied by the machine during a test.

This machine has scale ranges of 0 to 50,000 lb, 0 to 25,000 lb, 0 to 10,000 lb, 0 to 5,000 lb, and 0 to 2,500 lb. Tests were made using the 0- to-50,000-lb and the 0- to 10,000-lb scale ranges. These scale ranges are graduated into 50-lb and 10-lb divisions, respectively.

5. MACHINE *E*, FLUID-SUPPORT, BOURDON-TUBE, HYDRAULIC

The 100,000-lb capacity fluid-support, Bourdon-tube, hydraulic machine, designated as machine *E*, is shown in figure 5. The load is applied to specimens by the movable platens, *M*, which are moved by a hydraulic jack, *N*, having a packing. The force exerted by the specimen on the other platen, *O*, is transmitted as a compressive force to a fluid support under the hydraulic jack. The fluid support, having a flexible diaphragm, is connected hydraulically to Bourdon-tube pressure gages, *P*. The pointers of these gages move around graduated circular scales. There is no hydraulic connection between the hydraulic jack and the fluid support. The magnitude of the load is automatically indicated by the positions of the pointers. Maximum pointers are provided on each gage to indicate the maximum load applied during a test.

This machine has scale ranges of 0 to 100,000 lb, 0 to 50,000 lb, and 0 to 10,000 lb. These scale ranges are graduated into 200-lb, 100-lb, and 20-lb divisions, respectively. Tests were made using each scale range.

In this machine there is a throttle valve in the line from the hydraulic support to each Bourdon-tube gage to reduce the rate of return of the pointer after a specimen is broken. Instructions furnished by the manufacturer state that this valve should be open one-eighth to one-fourth turn when a gage is in use. Tests were made using valve openings within this range and in some tests with greater openings. Since no specimens were being broken during these tests, there was no danger of damaging the gages by using openings greater than one-fourth turn.

6. MACHINE *F*, FLUID-SUPPORT, BOURDON-TUBE, HYDRAULIC

The 75,000-lb capacity fluid-support, Bourdon-tube, hydraulic machine, designated as machine *F*, is shown in figure 6. The load is applied to the specimen by the movable platen, *M*. The load-weighing mechanism of this machine is similar in principle to the load-weighing mechanism of machine *E*. In machine *F*, however, the fluid support is located between the piston of the loading jack and the lower platen, *M*. The fluid support is connected hydraulically to two Bourdon-tube gages, *P*. These gages have scale ranges of 0 to 75,000 lb and 0 to 10,000 lb and are graduated into 100-lb and 20-lb divisions, respectively. Maximum pointers are provided to indicate the maximum load applied during a test. Tests were made using both scale ranges.

This machine is equipped with ball-check valves instead of the throttle valves furnished on machine *E*. These valves are designed to allow a free flow of oil under increasing loads and a throttled flow of oil under decreasing loads. The manufacturer's instructions state that this type of check valve should be open one full turn when a gage is in use. In all of the tests made on machine *F* the valves were open one full turn.

III. METHOD OF CALIBRATION

1. ELASTIC CALIBRATING DEVICE

(a) DESCRIPTION

The elastic calibrating device is shown in figure 7. The device consists of a steel ring, *A*, which is loaded in compression through the integral external bosses, *B* and *C*. The diameter of this ring is ap-

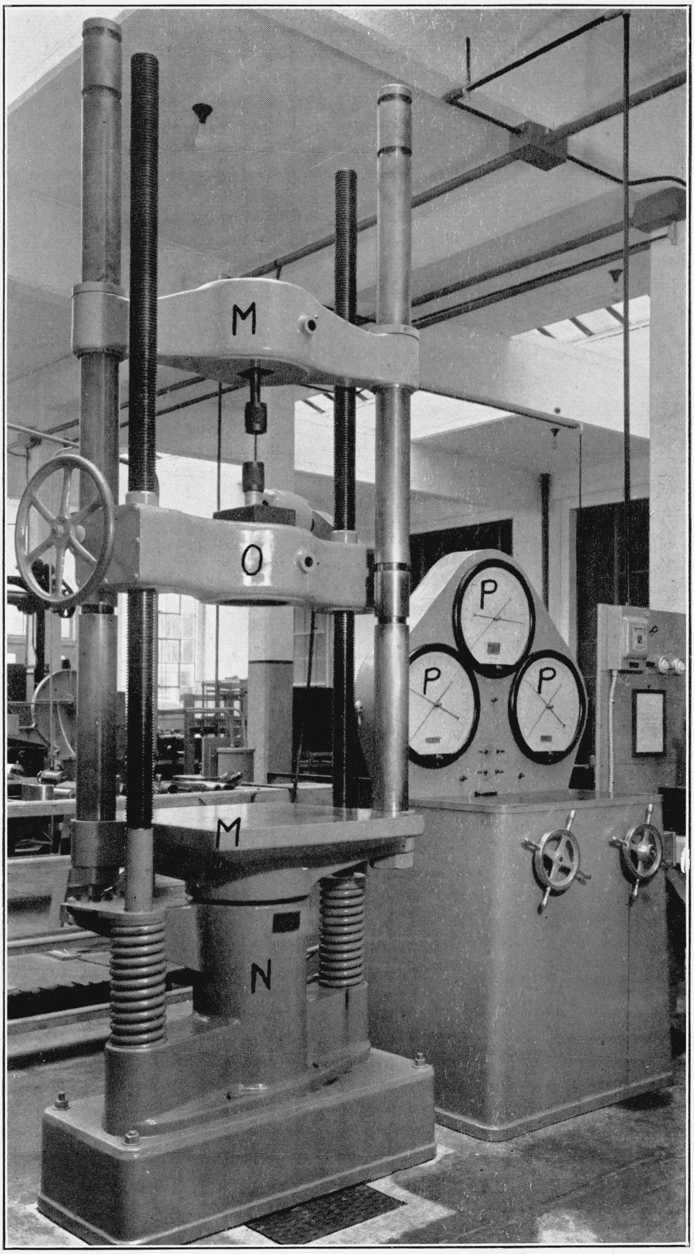

FIGURE 5.—*Machine E, 100,000-pound capacity fluid-support, Bourdon-tube, hydraulic testing machine.*

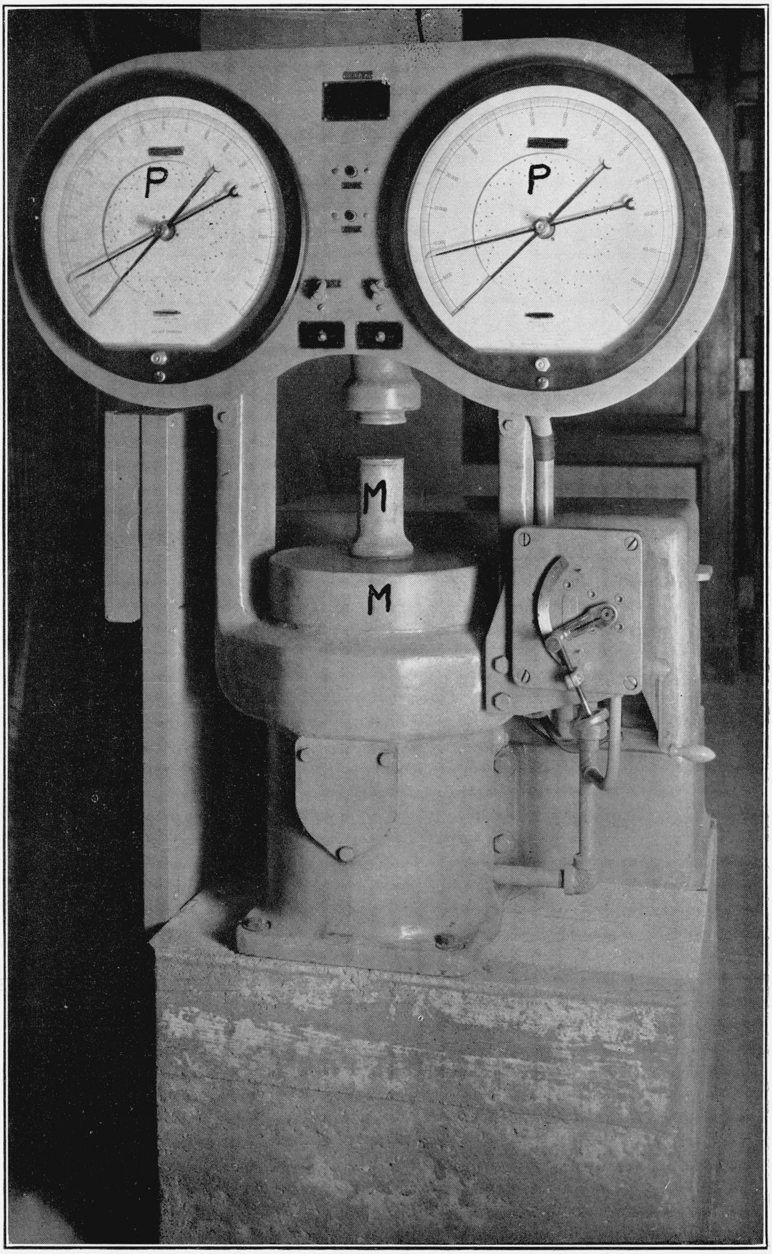

FIGURE 6.—*Machine F, 75,000-pound capacity fluid-support, Bourdon-tube, hydraulic testing machine.*

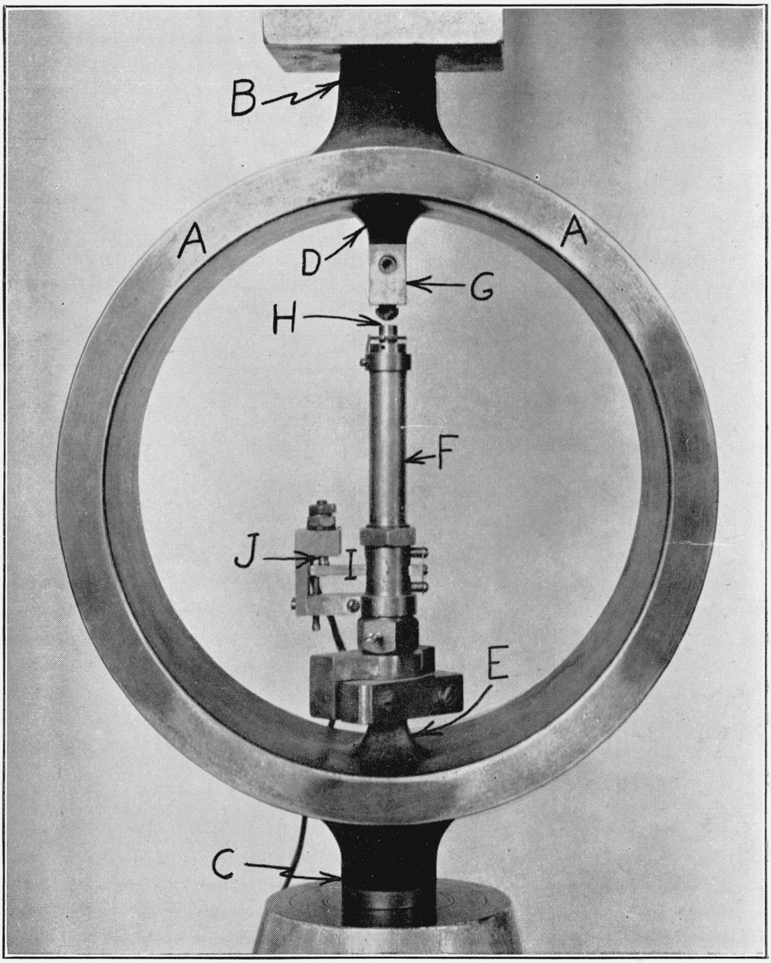

FIGURE 7.—*Elastic calibrating device, capacity 25,000 pounds.*

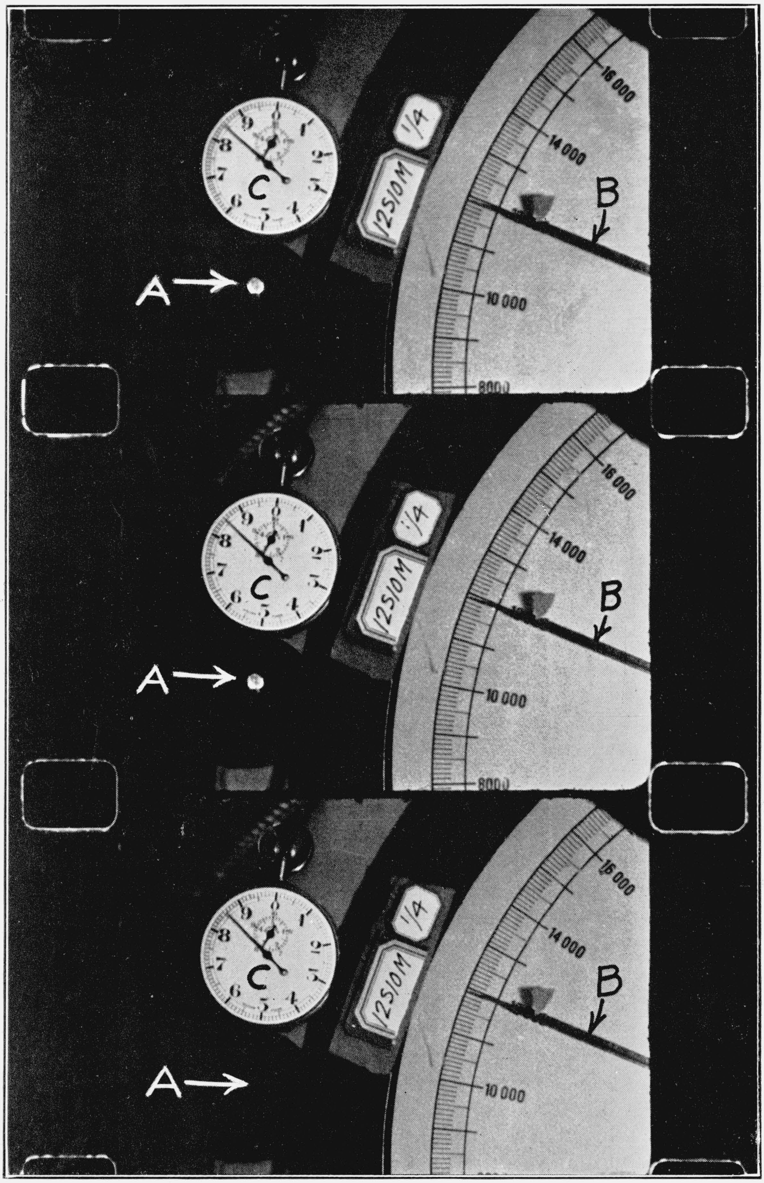

FIGURE 8.—*Reproduction of a strip of 16-millimeter film taken to record the dynamic reading of a testing machine.*

proximately 8 in. When a compressive load is applied to the ring, the loaded diameter shortens. This shortening can be measured by means of deflection measuring apparatus attached to the integral internal bosses, *D* and *E*. The deflection of the ring for its capacity load, 25,000 lb, was approximately 0.06 in. In these tests it was desired to have the elastic device indicate accurately when a given load had been applied to the ring. For this purpose the device was equipped with an electric contact, *F*, and an adjusting screw, *G*. The electric contact was devised by Charles Moon [3] of this Bureau. The electrical circuit of the contact is normally closed. When the ring is loaded so that the spherical head of the adjusting screw, *G*, pushes against the plunger, *H*, the lever, *I*, is actuated so that the electrical circuit is broken at the contact points, *J*. In these tests the contact was connected in series with a neon glow lamp and a source of direct current. When the device was in use the lamp would glow until the applied load for which the device had been set was reached. When this load was reached, the lamp would cease to glow.

(b) SENSITIVITY

Tests to determine how closely the elastic calibrating device would indicate a given applied load were made by loading the device with dead weights. These tests showed that the elastic calibrating device was sensitive to less than 2 lb for any load not exceeding the capacity load of the device.

(c) ERROR DUE TO INSTANTANEOUS TEMPERATURE EFFECT

The static load required to cause the lamp to cease to glow for a given adjustment of the elastic calibrating device, theoretically differs slightly from the dynamic load because of an instantaneous temperature effect. This error for proving rings was considered by L. B. Tuckerman [4] in his discussion of a paper by M. F. Sayre.[5] Calculations show that for the device used in these tests the error attributable to instantaneous temperature effect did not exceed 2 lb.

2. TESTING-MACHINE INDICATED LOADS

(a) STATIC

The indicated loads of the testing machines for a given adjustment of the elastic calibrating device were obtained under static conditions by reading directly the loads indicated by the machines at the instant the lamp ceased to glow. These readings were taken under very slowly increasing loads, but they will be referred to as "static" readings.

(b) DYNAMIC

The indicated loads of the testing machines for "dynamic" loading were obtained by photographing the lamp and parts of the testing-machine scales with a motion-picture camera. In each case the indicated load of the testing machine, read from the first frame of the film on which the lamp did not show, was taken as the dynamic reading of the machine for the rate of loading used. Camera speeds of 16, 32, and 64 frames per second were used.

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[3] J. Opt. Soc. Am. & Rev. Sci. Instr. **11**, 453–458 (1925).
[4] Proc. Am. Soc. Testing Materials **32**, II, 594–606 (1932).
[5] Proc. Am. Soc. Testing Materials **32**, II, 584–592 (1932).

The dynamic reading was greater than the actual indicated load of the testing machine at the instant the lamp ceased to glow due to the motion of the pointer between the instant the lamp ceased to glow and the time the next exposure was made. Calculations show that this error did not exceed 25 lb for the camera speeds and the rates of loading used.

Figure 8 shows three successive frames of film taken during a test on one of the machines. The lamp, *A*, can be seen in the two upper frames. The lamp had ceased to glow before the lower frame was exposed. The reading indicated by the pointer, *B*, in the lower frame was taken as the dynamic reading. The watch, *C*, was used to determine the rate of loading.

3. RATES OF LOADING

Two methods were used during these tests to determine the rates of loading of the testing machines.

For all tests except those made with the 0- to 50,000-lb scale ranges of machines *B* and *D* the rates of loading of the testing machines were determined from measurements of the time required to increase the load from 1,000 lb below to 1,000 lb above the load for which the elastic calibrating device was adjusted. This time was measured with a stop watch graduated to 0.1 second. For the tests made with the 0- to 50,000-lb scale ranges of machines *B* and *D*, a metronome was used to give audible signals at predetermined intervals of time and the operator adjusted the controls of the testing machines to maintain the desired rates of loading.

4. TESTING PROCEDURE

The elastic calibrating device was preloaded in the testing machine. The device was then adjusted so that the lamp ceased to glow at the desired static reading of the testing machine. Alternate static and dynamic readings were then taken, with this adjustment of the device, for different rates of loading up to approximately 50,000 lb/min (50 kips/min). Both static and dynamic readings were taken with and without the maximum pointers for all machines except machine *A*, which does not automatically indicate the load. In each case the readings taken with the maximum pointer were obtained with both pointers moving together and the readings taken without the maximum pointer were obtained after the maximum pointer had been previously advanced out of range. The errors due to rate of loading both with and without the maximum pointers were obtained by subtracting the static readings taken without the maximum pointer from the dynamic readings. The total error in the indicated load of a testing machine would be the algebraic sum of the error for static loads and the additional error due to rate of loading.

IV. RESULTS OF TESTS

1. MACHINE *A*

Machine *A* does not automatically indicate the magnitude of the load. The operator must move the poise to keep the beam balanced during the application of load. In order to determine the error due to rate of loading, two series of tests were made. In the first series of tests the operator kept the beam balanced to the best of his ability and the dynamic readings were recorded photographically. Since, in testing specimens, the indicated load of the testing machine is read after the operator has stopped moving the poise, a second series of tests was made to determine the error due to overrunning the poise.

The results of the tests in which the indicated loads of machine *A* for dynamic loading were obtained photographically are shown in figure 9. For each rate of loading readings were taken at 6, 13, and 18 kips, as indicated on the graph. The points show a considerable scatter above and below the 0-error axis, the scatter increasing with the rate of loading. This scatter is due primarily to the inability of the operator to keep the beam accurately balanced. Any error due

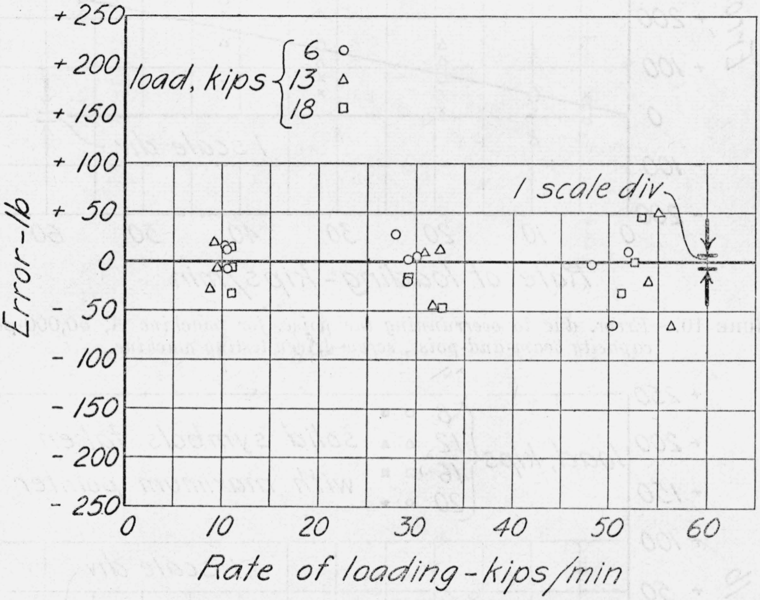

FIGURE 9.—*Error, due to rate of loading, for machine A, 50,000-pound capacity beam-and-poise, screw-driven testing machine.*

to rate of loading is so small that it is completely masked by the errors caused by the beam not being balanced.

In the second series of tests the lamp was placed near the trig loop of the machine and the operator stopped turning the handwheel, *P*, figure 1, as soon as possible after the lamp ceased to glow. The indicated load of the testing machine was read after the operator had stopped moving the poise. The results obtained by three experienced operators are shown in figure 10. Although there is considerable scatter of the points because of the inability of the operators to keep the beam balanced, there is a tendency on the part of each operator to overrun the poise. The average error due to overrunning the poise appears to be almost directly proportional to the rate of loading.

2. MACHINE *B*

The results of the tests made on machine *B* are shown in figures 11 and 12.

The results shown in figure 11 for the 0- to 50,000-lb scale range indicate that any error due to rate of loading is so small that it is

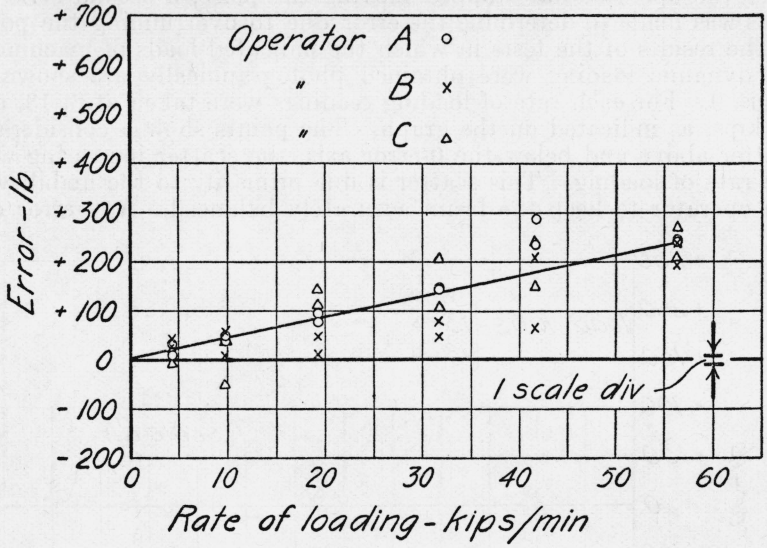

Figure 10.—*Error, due to overrunning the poise, for machine A, 50,000-pound capacity beam-and-poise, screw-driven testing machine.*

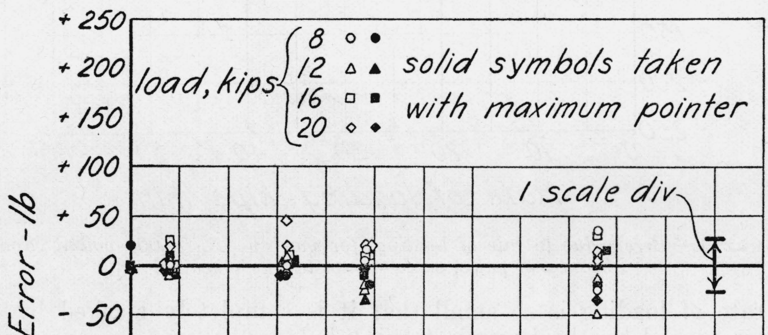

Figure 11.—*Error, due to rate of loading, for the 0- to 50,000-pound scale range of machine B, 50,000-pound capacity pendulum, hydraulic testing machine.*

completely masked by the scatter of the individual points. This scatter is caused by the fact that the machine does not indicate the same load for repeated applications of the same load. There appears to be practically no additional error due to the use of the maximum pointer.

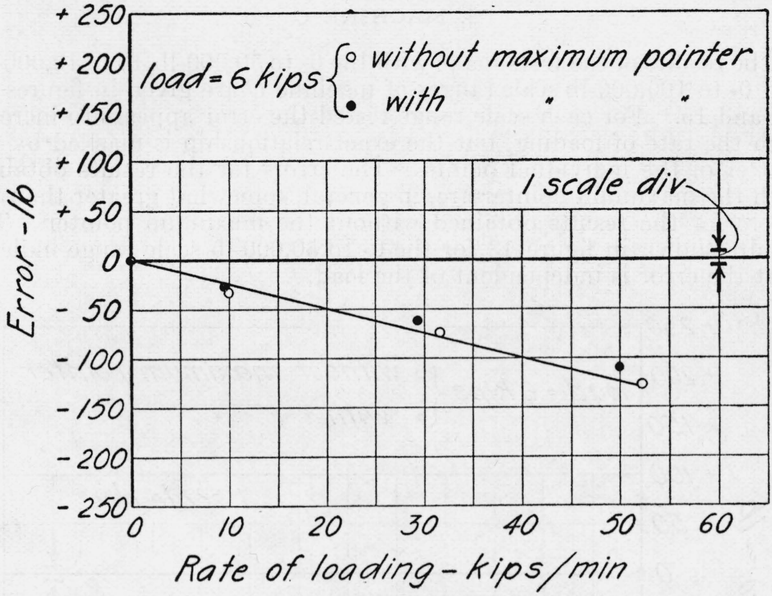

FIGURE 12.—*Error, due to rate of loading, for the 0- to 10,000-pound scale range of machine B, 50,000-pound capacity pendulum, hydraulic testing machine.*

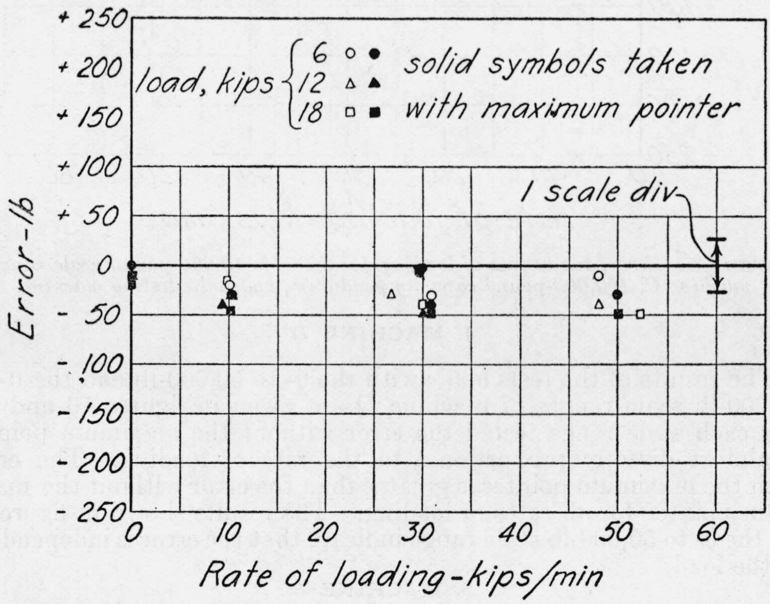

FIGURE 13.—*Error, due to rate of loading, for the 0- to 50,000-pound scale range of machine C, 100,000-pound capacity pendulum, hydraulic testing machine.*

The results given in figure 12 for the 0- to 10,000-lb scale range show that the error is almost directly proportional to the rate of loading.

There is little difference between the results obtained with and without the maximum pointer.

3. MACHINE *C*

The results of the tests made with the 0- to 50,000-lb, 0- to 10,000-lb, and 0- to 100,000-lb scale ranges of machine *C* are given in figures 13, 14, and 15. For each scale range tested the error appears to increase with the rate of loading, but the exact relationship is masked by the scatter of the individual points. The errors for the results obtained with the maximum pointer are, in general, somewhat greater than the errors for the results obtained without the maximum pointer. The results shown in figure 13 for the 0- to 50,000-lb scale range indicate that the error is independent of the load.

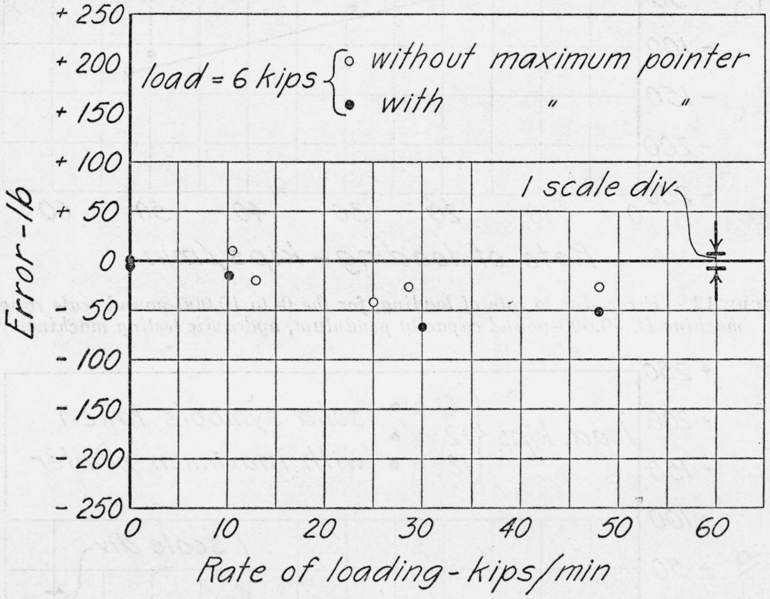

FIGURE 14.—*Error, due to rate of loading, for the 0- to 10,000-pound scale range of machine C, 100,000-pound capacity pendulum, hydraulic testing machine.*

4. MACHINE *D*

The results of the tests made with the 0- to 50,000-lb and the 0- to 10,000-lb scale ranges of machine *D* are given in figures 16 and 17. For each scale range tested the error without the maximum pointer is almost directly proportional to the rate of loading. The error with the maximum pointer is greater than the error without the maximum pointer for all rates of loading. The results shown in figure 16 for the 0- to 50,000-lb scale range indicate that the error is independent of the load.

5. MACHINE *E*

The results of the tests made with the 0- to 50,000-lb, 0- to 10,000-lb, and 0- to 100,000-lb scale ranges of machine *E* are shown in figures 18, 19, and 20.

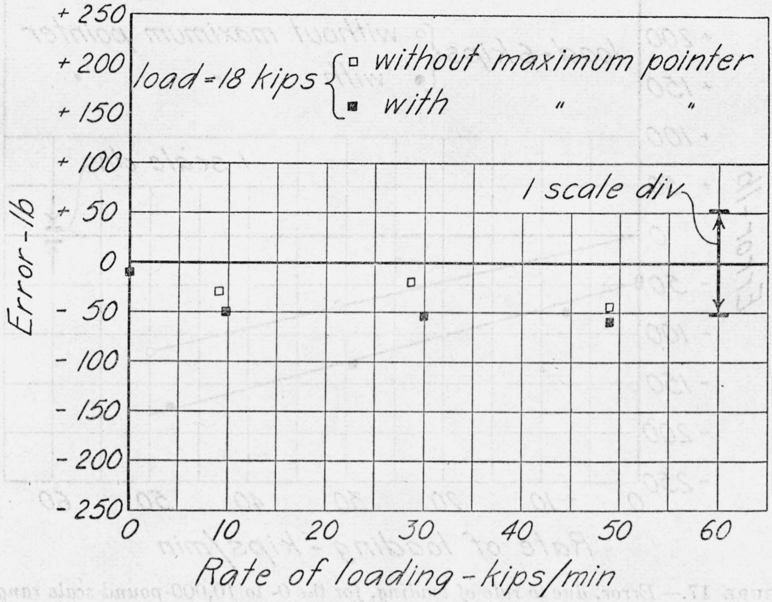

FIGURE 15.—*Error, due to rate of loading, for the 0- to 100,000-pound scale range of machine C, 100,000-pound capacity pendulum, hydraulic testing machine.*

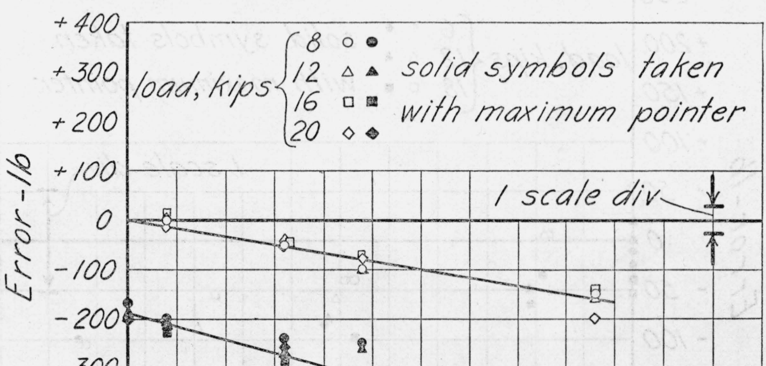

FIGURE 16.—*Error, due to rate of loading, for the 0- to 50,000-pound scale range of machine D, 50,000-pound capacity spring, hydraulic testing machine.*

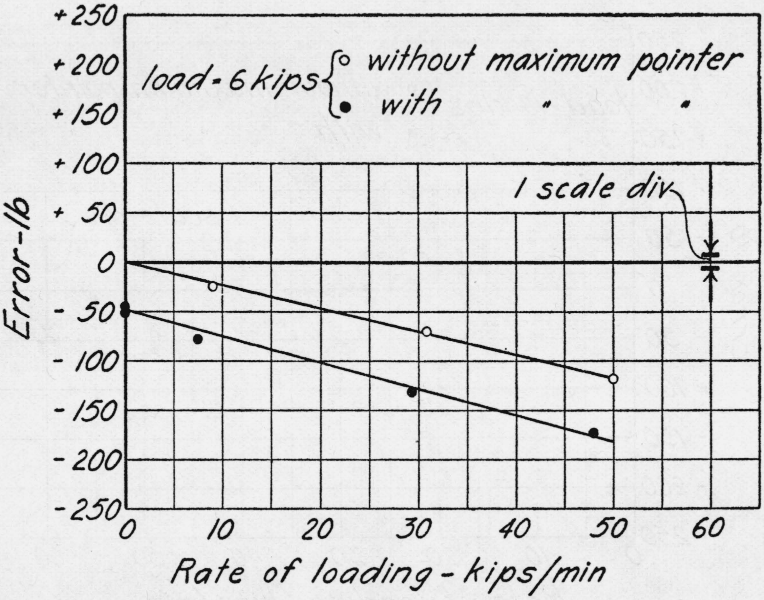

FIGURE 17.—*Error, due to rate of loading, for the 0- to 10,000-pound scale range of machine D, 50,000-pound capacity spring, hydraulic testing machine.*

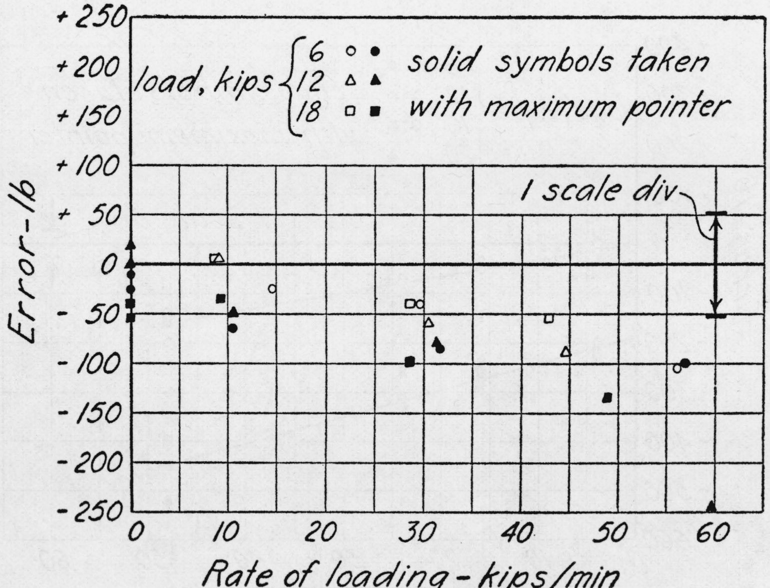

FIGURE 18.—*Error, due to rate of loading, for the 0- to 50,000-pound scale range of machine E, 100,000-pound capacity fluid-support, Bourdon-tube, hydraulic testing machine.*

[Gage throttle valve open one-fourth turn.]

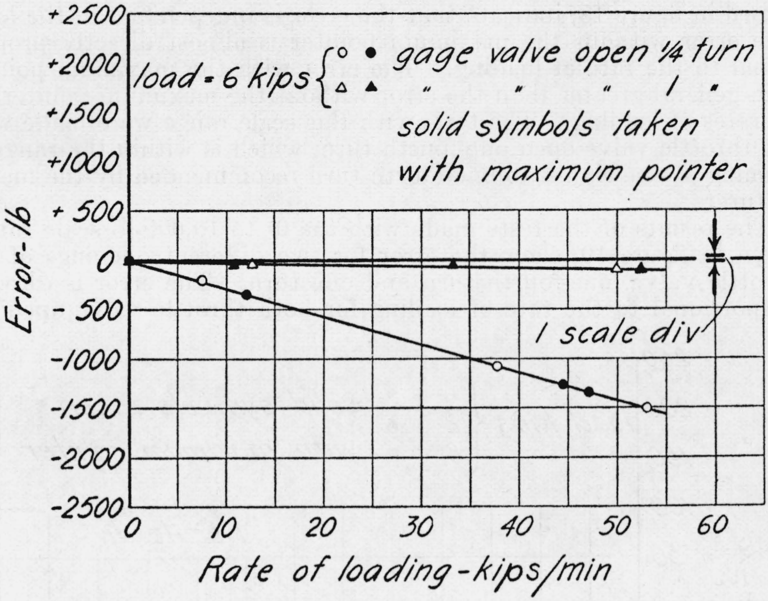

FIGURE 19.—*Error, due to rate of loading, for the 0- to 10,000-pound scale range of machine E, 100,000-pound capacity fluid-support, Bourdon-tube, hydraulic testing machine.*

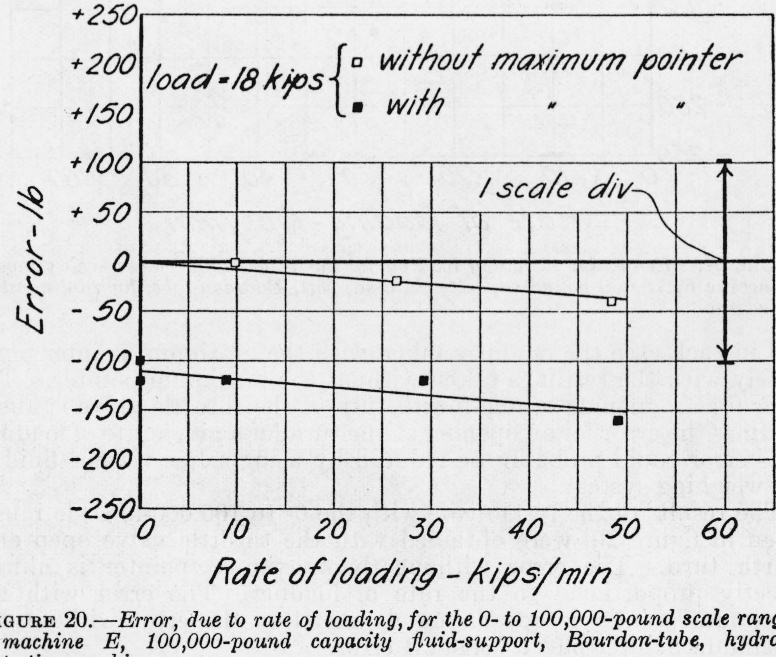

FIGURE 20.—*Error, due to rate of loading, for the 0- to 100,000-pound scale range of machine E, 100,000-pound capacity fluid-support, Bourdon-tube, hydraulic testing machine.*

[Gage throttle valve open one-fourth turn.]

The results of the tests made with the 0- to 50,000-lb scale range, as shown in figure 18, indicate that the error is independent of the load. The error without the maximum pointer is almost directly proportional to the rate of loading. The error with the maximum pointer is in general greater than the error without the maximum pointer for all rates of loading. The tests with this scale range were made with the throttle valve open one-fourth turn, which is within the range of opening of one-eighth to one-fourth turn recommended by the manufacturer.

The results of the tests made with the 0- to 10,000-lb scale range, given in figure 19, show the error for two different openings of the throttle valve, one-fourth turn and one turn. The error is directly proportional to the rate of loading for both throttle valve openings

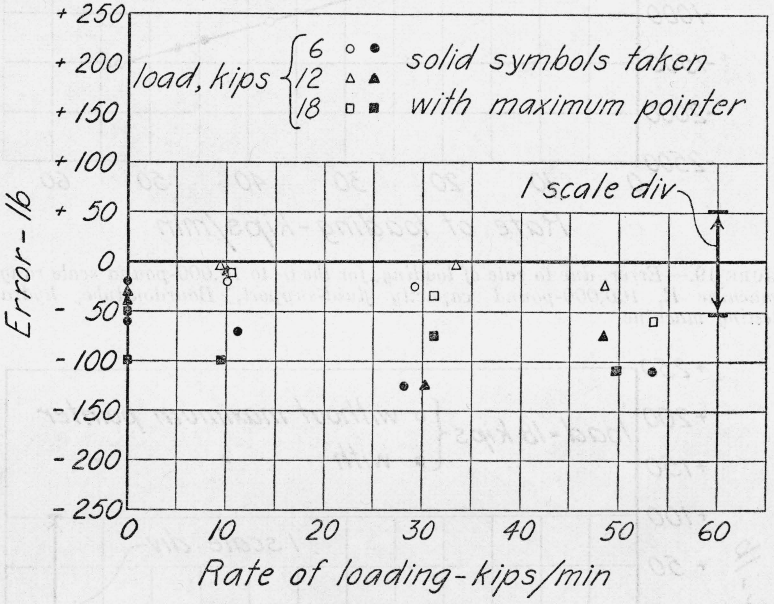

FIGURE 21.—*Error, due to rate of loading, for the 0- to 75,000-pound scale range of machine F, 75,000-pound capacity fluid-support, Bourdon-tube, hydraulic testing machine.*

and in each case the readings taken with the maximum pointer agree closely with the readings taken without the maximum pointer. The error for an opening of one-fourth turn of the throttle valve is about 15 times the error for an opening of one turn for a given rate of loading. This error could probably be reduced by using a less viscous fluid in the weighing system.

The results of the tests made with the 0- to 100,000-lb scale range, given in figure 20, were obtained with the throttle valve open one-fourth turn. The error without the maximum pointer is almost directly proportional to the rate of loading. The error with the maximum pointer is approximately equal to the error without the maximum pointer plus a constant error.

6. MACHINE *F*

The results of the tests made with the 0- to 75,000-lb and 0- to 10,000-lb scale ranges of machine *F* are given in figures 21 and 22. For both scale ranges the errors without the maximum pointers appear to be almost directly proportional to the rate of loading and in each case the error with the maximum pointer is greater than the error without the maximum pointer for all rates of loading. The results of the tests made with the 0- to 75,000-lb scale range, given in figure 21, indicate that the error is independent of the load.

7. EFFECT OF ERROR DUE TO RATE OF LOADING ON LOADING RANGE

The American Society for Testing Materials [6] defines the loading range of a testing machine as the range of indicated loads for which

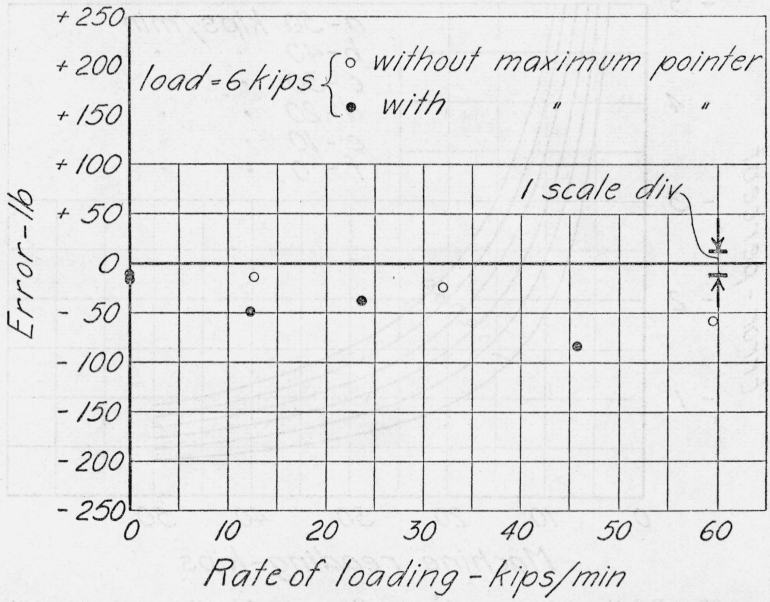

FIGURE 22.—*Error, due to rate of loading, for the 0- to 10,000-pound scale range of machine F, 75,000-pound capacity fluid-support, Bourdon-tube, hydraulic testing machine.*

the testing machine gives results within a tolerance of ±1 percent. The loading ranges of testing machines are usually determined for static loads. The additional errors, due to rate of loading, will, in general, decrease the loading ranges.

The relation between the machine reading, the rate of loading, and the error with the maximum pointer, due to rate of loading, for the 0- to 50,000-lb scale range of machine *D* is shown in figure 23. The curves were computed from values taken from figure 16. It is clear from figure 23 that even if the errors for static loading without the maximum pointer were zero, the loading range would be greatly reduced by the use of the maximum pointer and still further reduced by increasing the rate of loading.

[6] Am. Soc. Testing Materials Standards I, 849–860 (1936).

V. CONCLUSIONS

Six testing machines comprising four different types were calibrated for rates of loading up to approximately 50,000 lb/min by means of a special elastic calibrating device. The error due to rate of loading was determined with and without the maximum pointers for all machines except machine *A*, the beam-and-poise, screw-driven machine. The error due to overrunning the poise of machine *A* was determined.

For each scale range for which the relationship between the error due to rate of loading, determined without the maximum pointer, and the rate of loading could be determined, the error was almost directly proportional to the rate of loading. For all machines showing an effect the indicated load of the machine was less than the applied load.

For the one scale range of each machine tested at different loads the error due to rate of loading was independent of the applied load.

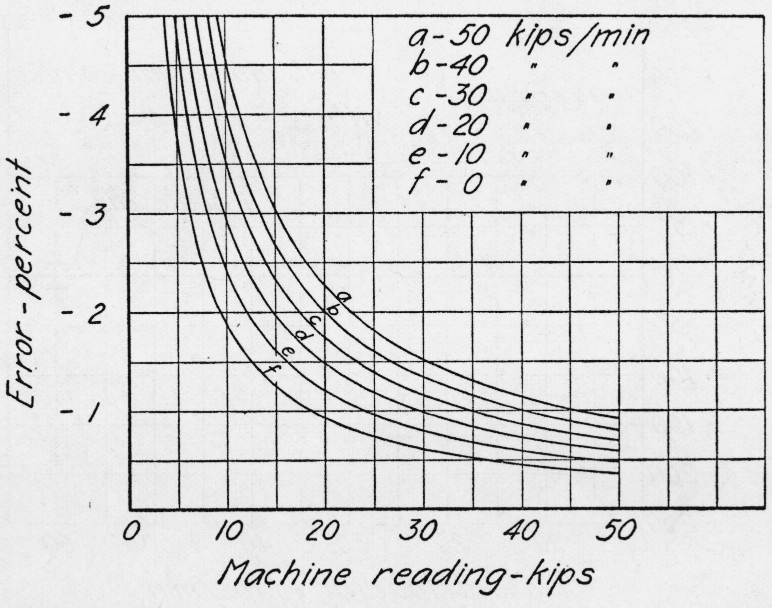

FIGURE 23.—*Relation between machine reading, rate of loading, and error with the maximum pointer for the 0- to 50,000-pound scale range of machine D, 50,000-pound capacity spring, hydraulic testing machine.*

The additional error due to the use of the maximum pointer was in some cases as great as −200 lb, while in other cases it was too small to be measured by the methods used. This error could probably be reduced for some of the scale ranges of some of the machines, but no special adjustments were made to the maximum pointers before or during these tests.

The error caused by overrunning the poise of machine *A* appears to be almost directly proportional to the rate of loading. For this machine only, the indicated load was greater than the applied load.

The additional errors, due to rate of loading, of the testing machines calibrated, at rates of loading currently used in testing, exceeded in several cases the tolerances specified for testing machines. These errors, therefore, cannot in general be neglected when determining the rates of loading to be used in materials testing.

The errors caused by the rate of loading of different testing machines of the same type may differ materially because of small inherent differences in the weighing systems and slight differences of adjustment. For this reason the results of these tests cannot be used to correct the load readings of other testing machines of the same types.

WASHINGTON, April 12, 1937.