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Highlights of the Division of Highways Physical Research Program

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By

John L. Beaton
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It had been my plan to open this talk with a statement that the Materials and Research Department of the Division of Highways had been organized by the State Highway Commission in 1912 and that the Division of Highways had been aggressively pursuing research since that time and further because of the sophistication of our times, research today was even more necessary than in those days.

However, the other day I picked up a copy of the first issue of the California Highway Bulletin and read from a report by A. B. Fletcher, the first State Highway Engineer, the following:

> "The reporters advocate the asphaltic concrete type of pavement for general use, and I agree that it is an excellent pavement, although I prefer a road with a hydraulic cement concrete base to one consisting wholly of bituminous concrete."

Since this is essentially the same type of pavement we are building today, there might be some question in some

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people's minds about how much good our research has really done. While I am quoting, I thought maybe you would like to hear another quote from the same issue of the California Highway Bulletin.

> "The Highway Commission supported the movement started by the civic section of the California Federation of Women's Clubs of the Northern District for the protection of the State highway system against the hideous road sign which obliterates the landscape and mars the view of the scenery along nearly all of California's Highways..."

Again I wonder if we have changed much. Actually we have changed and advanced a great deal even though we primarily still use stone, asphalt, portland cement, steel and earth in the majority of our construction of highways and we still have billboards.

Our improvements insofar as materials are concerned have been in the direction of better balanced pavement designs, better utilization of all materials, practical specifications that encourage contractor efficiency, tests that are faster and more accurate, etc. On the physical research side, most of the improvements are probably not as spectacular nor as obvious as the improvements that have been made on the geometric side, but they have helped make such improvements possible.

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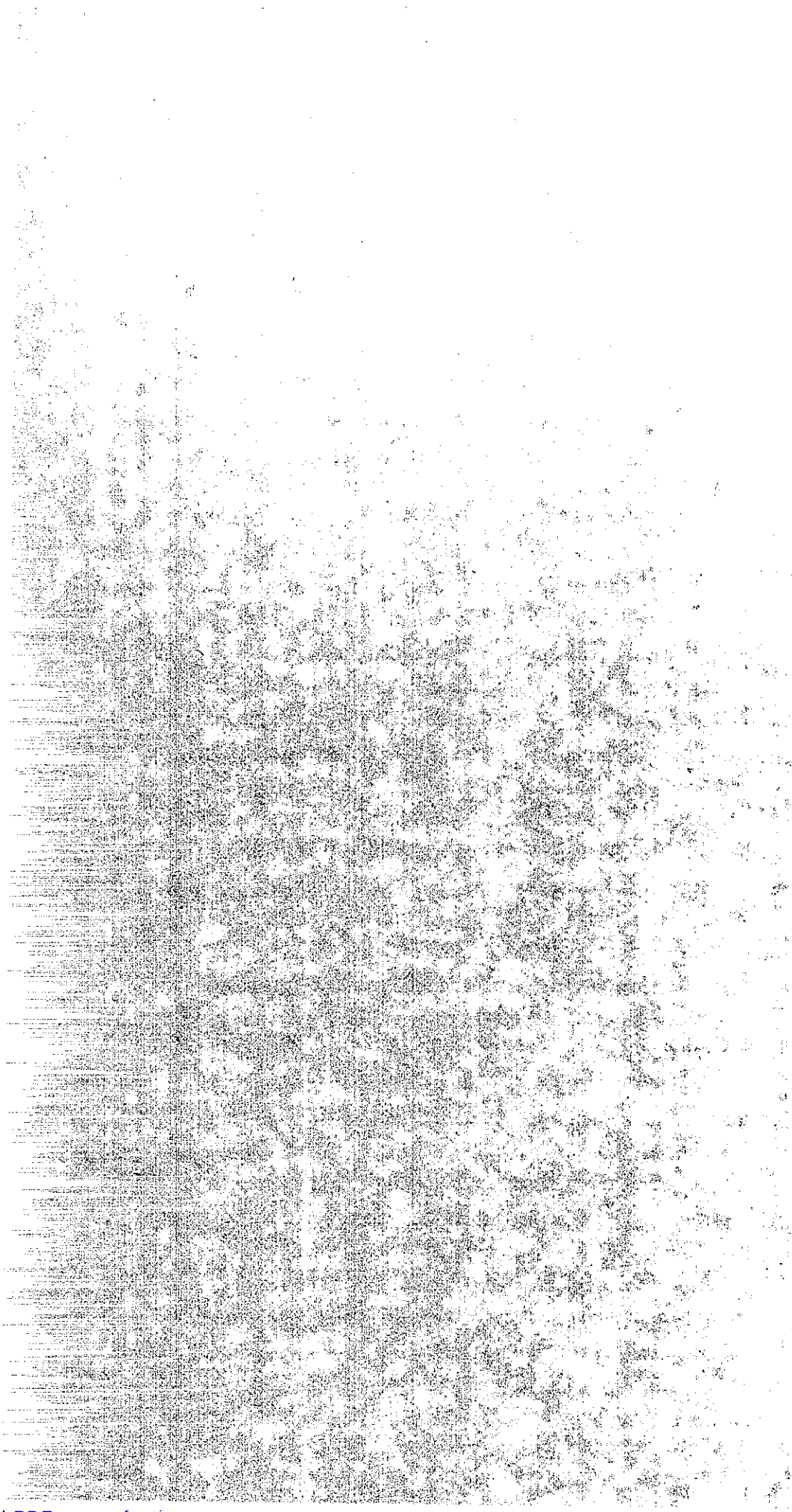

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The development of our tremendously efficient freeway of today required not only extensive research into the requirements of the travelling public but also from the days of 1912, a complete change in philosophy. In those days, for instance, a bridge was built in the most economical location and the road was bent and befuddled to fit. Now the needs of traffic dictate the placement of the facility and the bridge is merely another part of the complex hardware of highway construction. In addition, the highway fill has changed from a pile of dirt to another complex structure.

Until recently, research was not identified as such in the California Division of Highways budgets. Therefore, it is difficult to trace the monies that were actually spent during any one year. However, in taking a guess from the size of the laboratory and the amount of construction under way, it is probable that they did not spend over $500 on research during the year 1912. This has progressed to the point of our overall budget for research in the Division in this fiscal year is approximately $2.5 million while $3.6 million is proposed for the 1967-68 work.

My primary purpose today is to report to you on the current status of our physical research underway. But before doing this, I would like to establish a definition of research insofar as we in the Materials and Research Department of the Division of Highways are concerned. We think of research as

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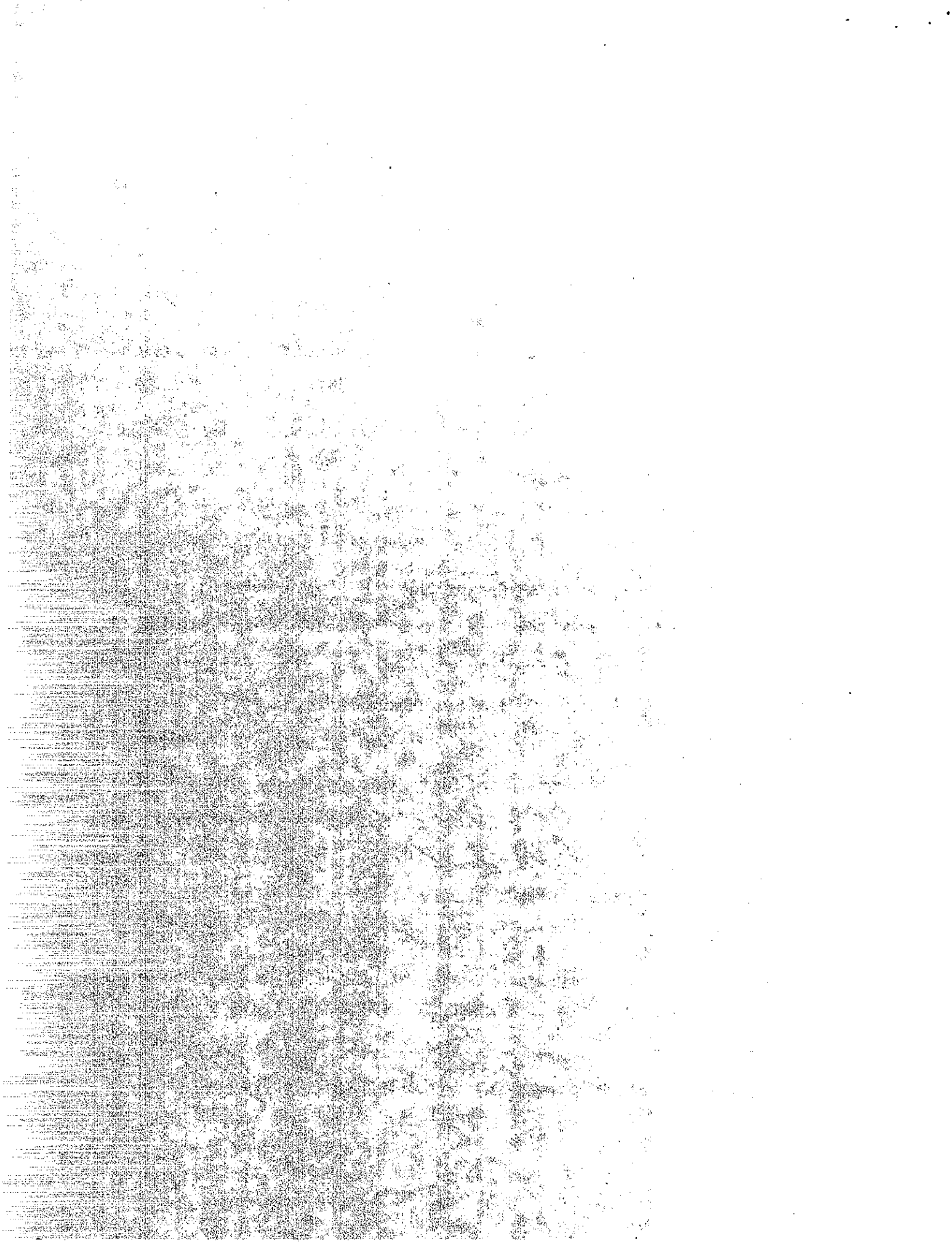

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normally involving experimentation and that it is practically always an organized investigation of a scientific problem. Traditionally, this type of research has been divided into pure and applied, with the pure type being primarily a search for information while the applied is to solve a specific problem. In the Division of Highways, we finance and sponsor both types, but insofar as "in-house" performance is concerned, we do only applied research. Pure research, we feel, is the province of the universities and encourage their work in such areas. Insofar as applied research is concerned, by policy we perform all of this type that we are manned and equipped to do. The reason for this is that we are close to our specific problems and also that most of such research involves working on the traveled way or on construction projects. As you can well understand, an outline of instructions as well as safety training and protection under these conditions probably takes as much manpower as is involved in the project itself.

As indicated earlier, we have had research underway since 1912. This work has been pursued with considerable success. For instance, all of the following problems have been pretty well solved due to the activities of the Materials and Research Department:

Rutting of an asphalt pavement on a state highway is practically nonexistent due to our research and development of tests for pavement design. As a matter

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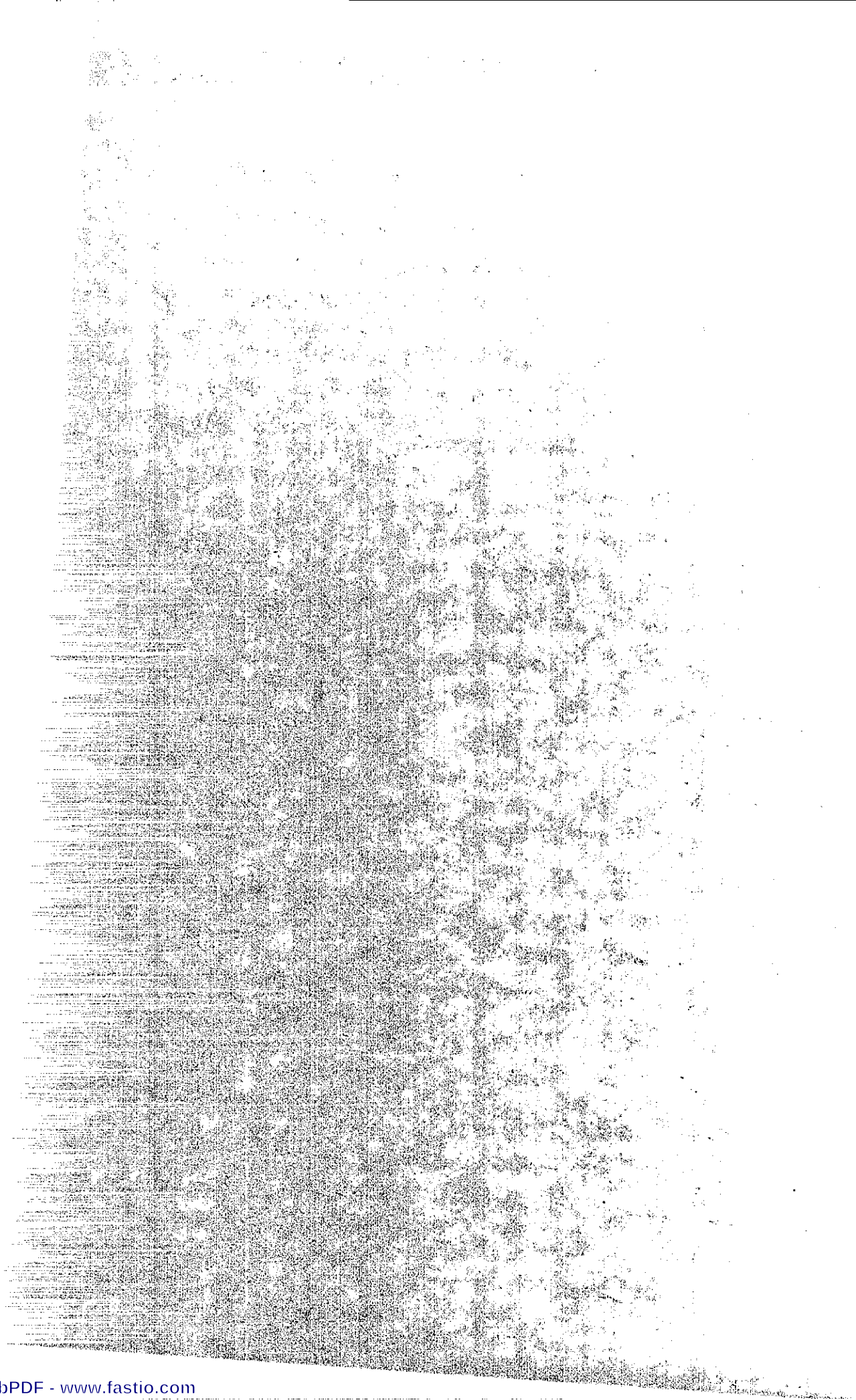

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of fact, the design procedure of the Division of Highways for flexible pavements has been refined to the point where it can be truly said that our pavements are an engineering structure even though the design is still empirical.

Our work in developing shrinkage controls for concrete should result in longer lived and better performing structures.

Our development of prequalification and welding controls for welding the various structural steels has resulted in the use of welding almost exclusively in our steel structures.

The one type of fatal accident which has shown a marked decrease during the past six years has been the cross median type. The use of median barriers developed by full scale crash tests has been instrumental in this decrease.

Ten to twenty years ago when a concrete pavement failed, it was usually because of pumping. This has been eliminated by the development and use of cement treated bases.

In the area of stabilizing foundations and cut slopes, vertical sand drains were invented and developed by the Materials and Research Department so as to stabilize highways across soft foundations, and the use of horizontal drains was developed so as to stabilize cut slopes.

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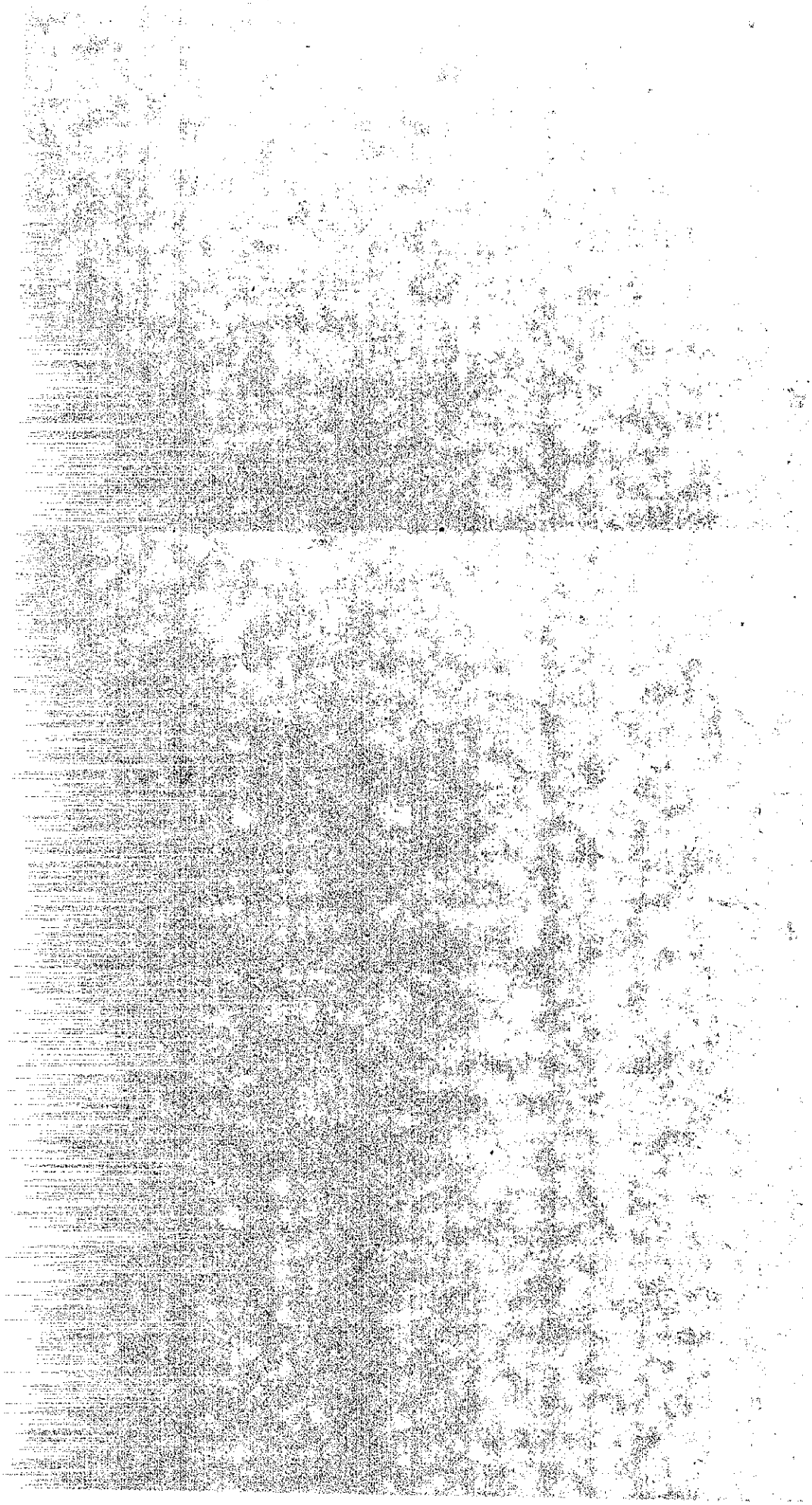

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Raised marker traffic lines have been adopted by the Division as standard. The white raised marker was developed in our Chemical Laboratory as well as the procedure that made such markers both reflectorized and nonreflectorized feasible. This is the use of epoxies to fasten the markers securely to the roadway.

This year, a total of $2,589,000 has been allocated to research. This covers all types of research involved in improving the overall highway transportation program of the State of California and ranges from research into driver performance through land economic, geographic and sociological effects of highway placement to the physical type of research which we perform in my agency, the Materials and Research Department.

I suppose you are all familiar with some of the new terminology that has developed in our field recently - the words "hard" and "soft" are used to describe the difference between the physical type of research required in the fields of materials, construction, and design, and the data collection and analyzing type of research performed in the legal, right of way, planning, and accident areas.

Of the budget of $2.5 million, the Division of Highways performs or directs research in the amount of $2,300,000 while other units of the Transportation Agency, such as the Highway Patrol and Motor Vehicle Department, conduct the balance. Of the Division of Highways budget, $1,400,000 of this work would be classified as "hard" research and the balance of $900,000 as "soft" research.

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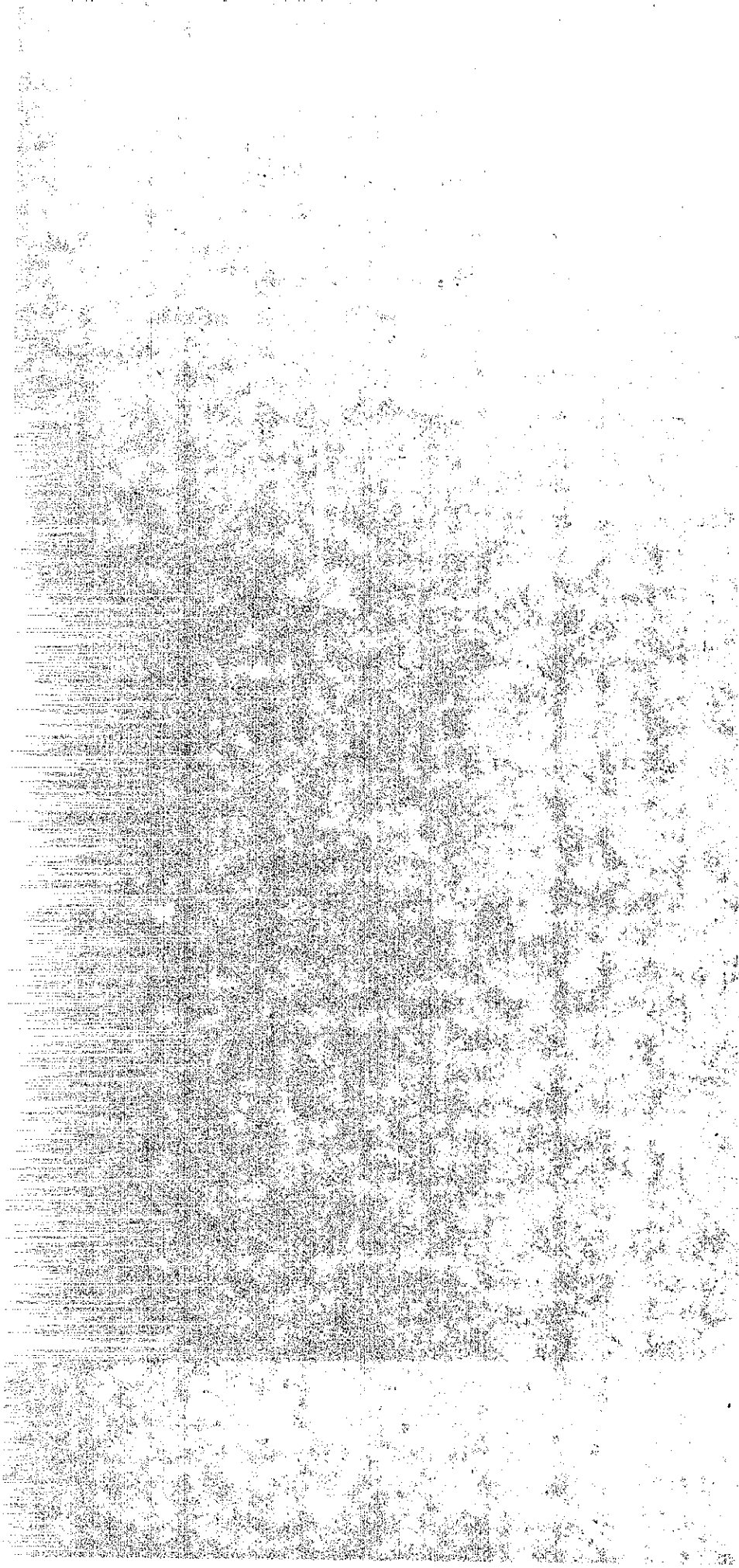

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While my talk will be oriented around the work directly performed by the Materials and Research Department, which is almost entirely in the physical or "hard" areas, I thought you might be interested in a sampling of some of the types of "soft" research being performed. I will merely read the titles (which are descriptive) of some of the projects under way so as to give you some idea of the breadth of this work.

Relationship and Effect of Freeway Location on Schools

Driver Performance of Persons Involved in Fatal Accidents

Alcohol, Drug, and Organic Factors as Causative Factors in Single Vehicle Fatal Accidents

Relation of Roadway Elements to Accidents

Young Driver Follow-up Study

Exploratory Work on Problem of Reduced Visibility

Alcohol Level and Driving Performance

Mental Illness as a Factor in the Occurrence of Traffic Accidents

Mechanical Factors in Fatal Single Vehicle Motor Vehicle Accident

The Effects of Fatigue on Driving Skills and Related Judgments

As indicated earlier, our physical research budget amounts to about $1,400,000. Of this, I am directly responsible for about $1,000,000 and during the year will provide research assistance to others in the amount of about $200,000. The others

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are those responsible in the Division for the remaining $400,000 expenditure on physical research this year. This work is divided between our Bridge Department and Traffic Department, although there are a few projects assigned to other Departments and Districts within the Division. Within the Materials and Research Department, we have 106 active (67 Federal - 39 State) projects under way which are estimated will eventually cost about $6,200,000. Most of these projects are spread over several years, some are terminating this year, while others are just being initiated. I would like to show now a few slides illustrating some of the projects which we have under way. I have selected those which I feel will give you an idea of the breadth of our work and also will have some current interest to this audience.

The first slide illustrates the starting point of all research and is one of the few "soft" research projects we have underway.

Investigate the Use of a Rapid Library Data Retrieval System

Movements Within Large Fills

Effects of Method B Backfill on Flexible Metal Culverts under High Earth Embankments (Chadd Creek)

Apple Canyon Culvert Study (Method A Backfill)

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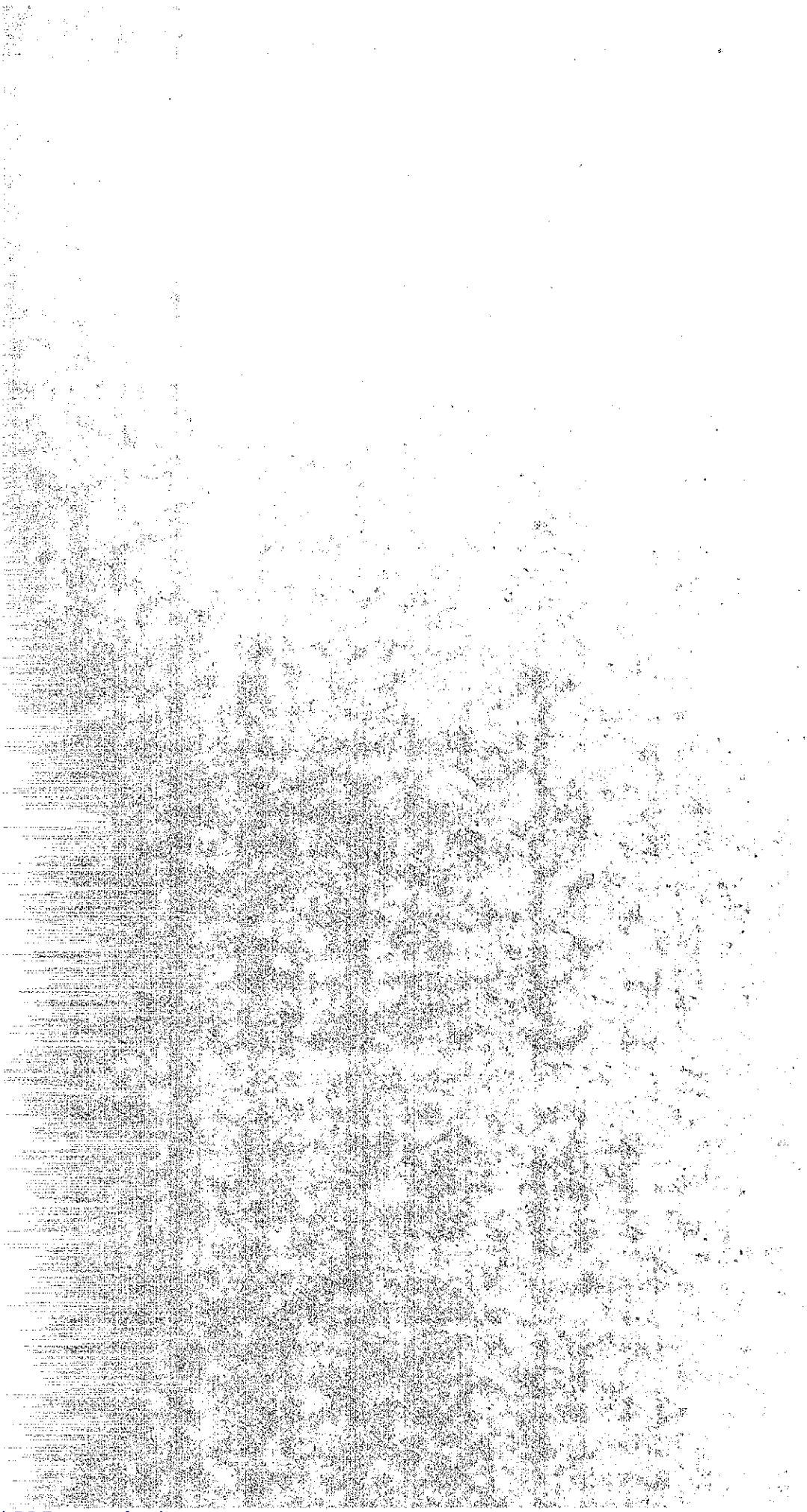

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Evaluation of Problems in the Field Use of Nuclear Moisture and Density Gages in Construction Control

Investigate Use of Lime for Treating Clay Basement Soil for Use as a Base Under A.C. Surfacing

Durability of Paving Asphalts

Statewide Deflection Study

Testing and Trial Installation of Thin Resinous and Aggregate Overlay of P.C.C. on Highway and Bridge Decks

Corrosion of Steel in Concrete

The Corrosion Prevention of Prestressing Steel

Develop Jointing Procedures for Reinforcing Steel Bars (Including Mechanical Couplers)

Orthotropic Deck Plate Research

Traffic Noise Near Highways

Study Statistical Method of Quality Control

Skid Resistance of Paving Surfaces

Prevention of Wrong-Way Movement on Off-Ramps

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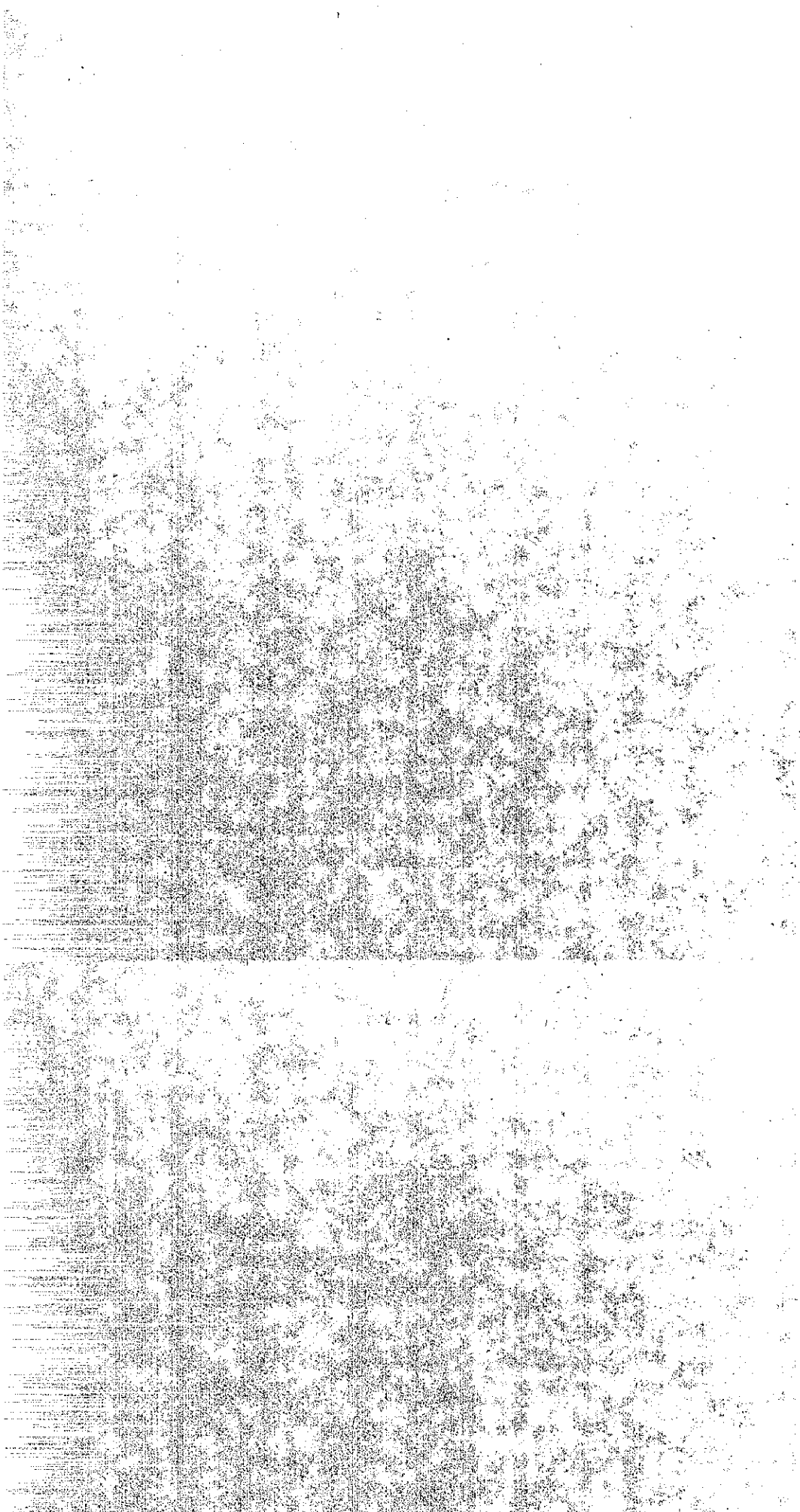

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Dynamic Tests of Aluminum Bridge
and Median Barrier Railings

Texas Sign Study

Evaluation of the Efficiency and
Effectiveness of Short Guard Rail
and Median Barrier Installation

This last chart shows the summary of a report which we make yearly to the State Highway Engineer. The report shows the research jobs which have been completed during the past three years along with their actual or anticipated savings. Such figures are virtually impossible to determine with complete accuracy, so these charts only represent a "Best estimate". It is possible to project with a fair degree of confidence that research completed two or three years ago will definitely develop a benefit-cost ration of at least 4 - 1 over a 10-year period.

It is also possible to estimate that the total benefits might run as high as 15 to 1 over the same period. The difference between these two figures represents the benefits which might be documented by reduced bid costs, or other equally reliable criteria, and those which can only be estimated. For example, how much savings can be effected from a corrosion prevention study on culverts? This can be estimated but not documented without an elaborate bookkeeping system. On the other hand, we

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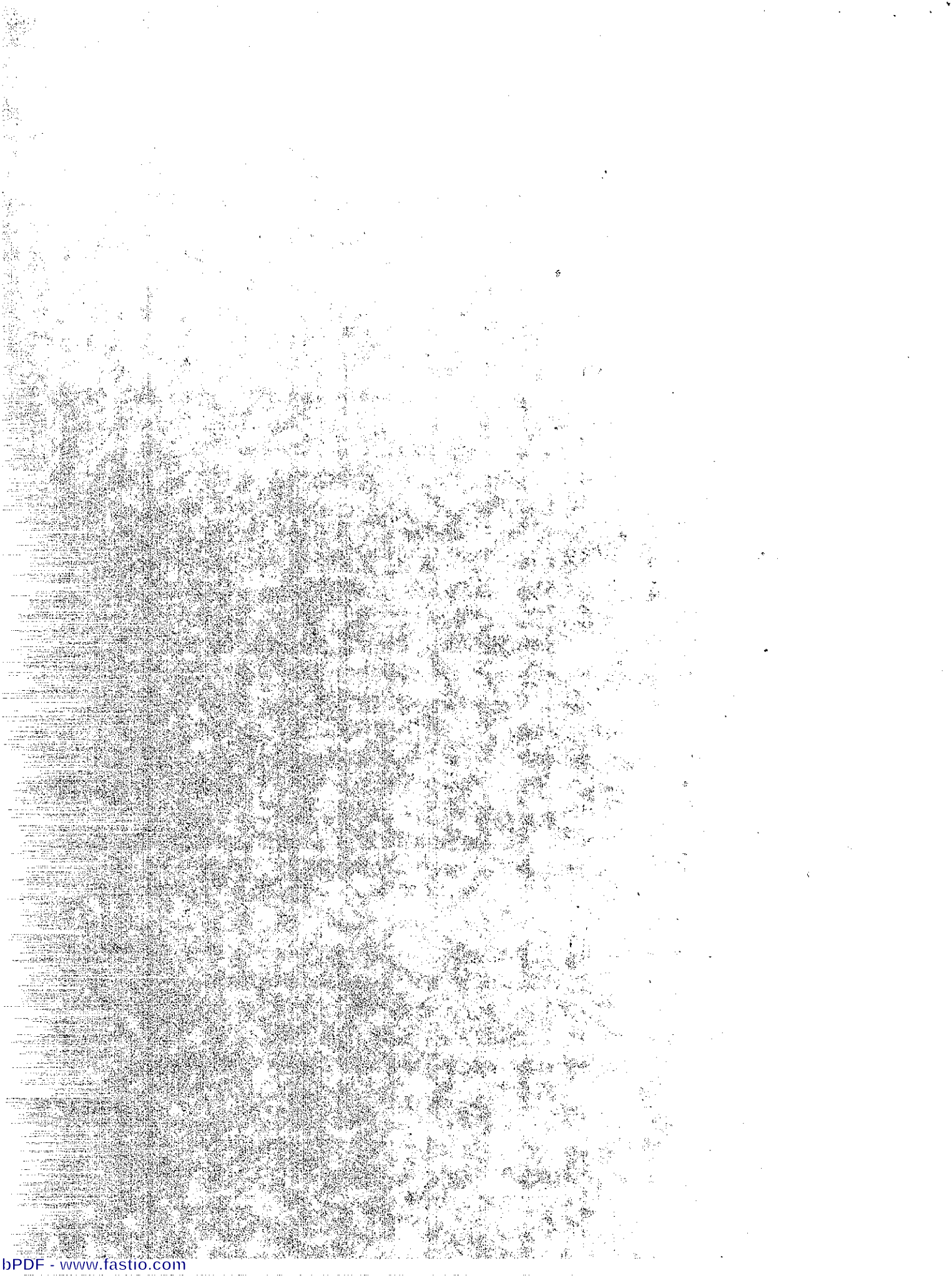
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developed a new gradation specification for permeable material and dropped the price from $7.50 per yard to $3.00 per yard. This project cost $9,000 and based on our average yearly tonnage, our profit is $500,000 per year.

In addition to the cost benefits, however, there are many intangible benefits which result from highway research and which are not measurable on a cost basis. Some of these benefits which defy evaluation are in the field of safety. For instance, how would you evaluate the savings in lives caused by improved median barrier design? In a recent tabulation issued by our Traffic Department for the year 1964-65, we have noted that in spite of increased traffic and increased number of miles of divided, cross median traffic accidents show a marked decrease in number and in fatalities when compared to 1962-63. The fact that the decrease took place during a period when other accidents increased reflects, we believe, the effect of improved median barrier design through research. But how would you evaluate the reduction in the number of fatalities from 132 to 85? How much is our life worth?

One objective of a present study in progress is to develop criteria which will allow us to predict the noise level expected from a particular freeway design and to keep this level at a minimum due to proper design. While this will result in better relationships with the public and there is also some monetary benefit to be achieved through reduced community meetings

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or in settling disputes without litigation, maybe the highest benefit is to humanity. Improved design embodying the factors developed in our skid resistance studies, in our bridge rail and guardrail studies, and many other areas will all result in improved highway design but not necessarily in calculable dollars and cents savings.

Fortunately, as an engineer, satisfaction is not always measured in dollars and cents, and I find that the satisfaction from these benefits which save lives and reduce accidents is much greater than that achieved from research which leads to definite dollars and cents savings.

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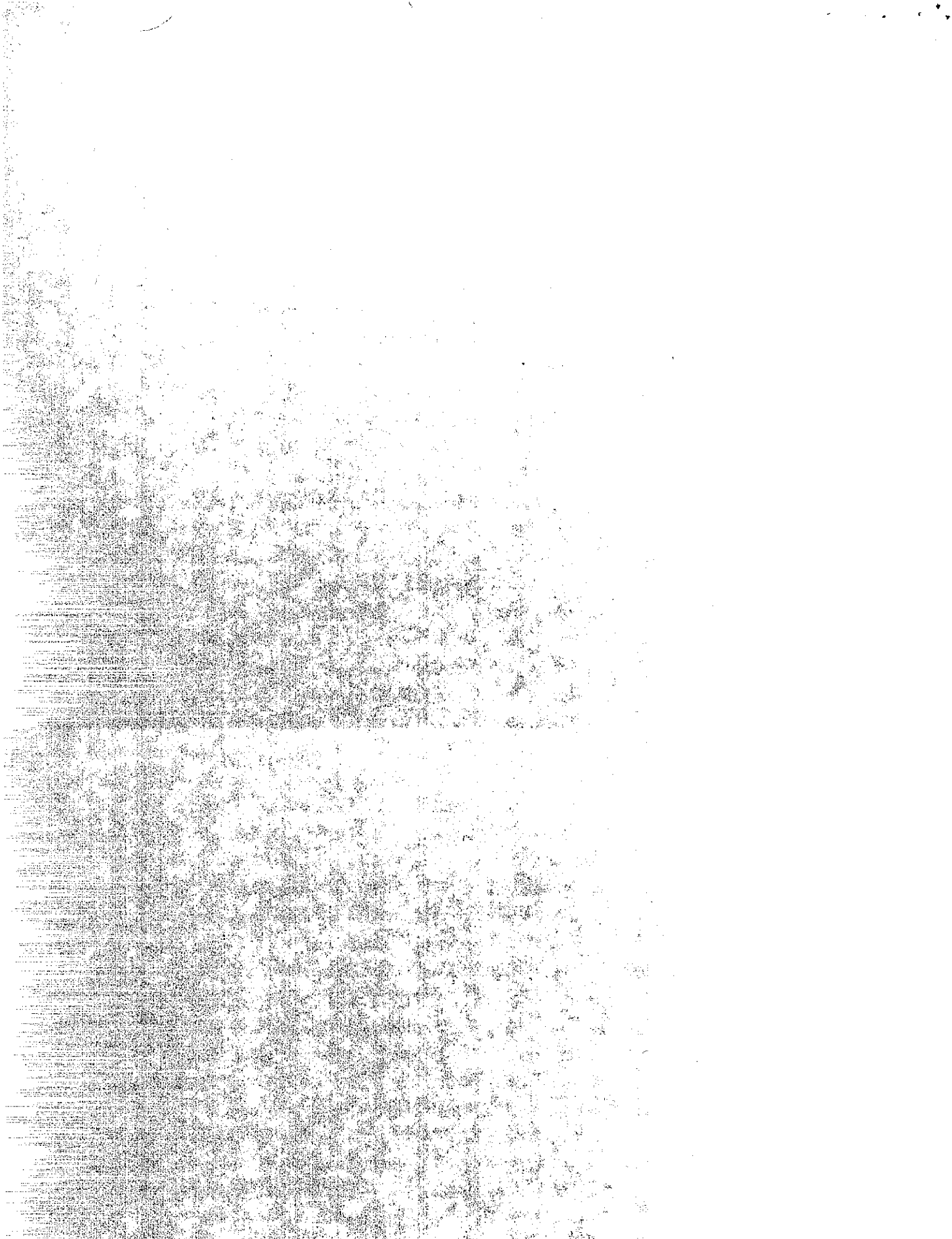

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