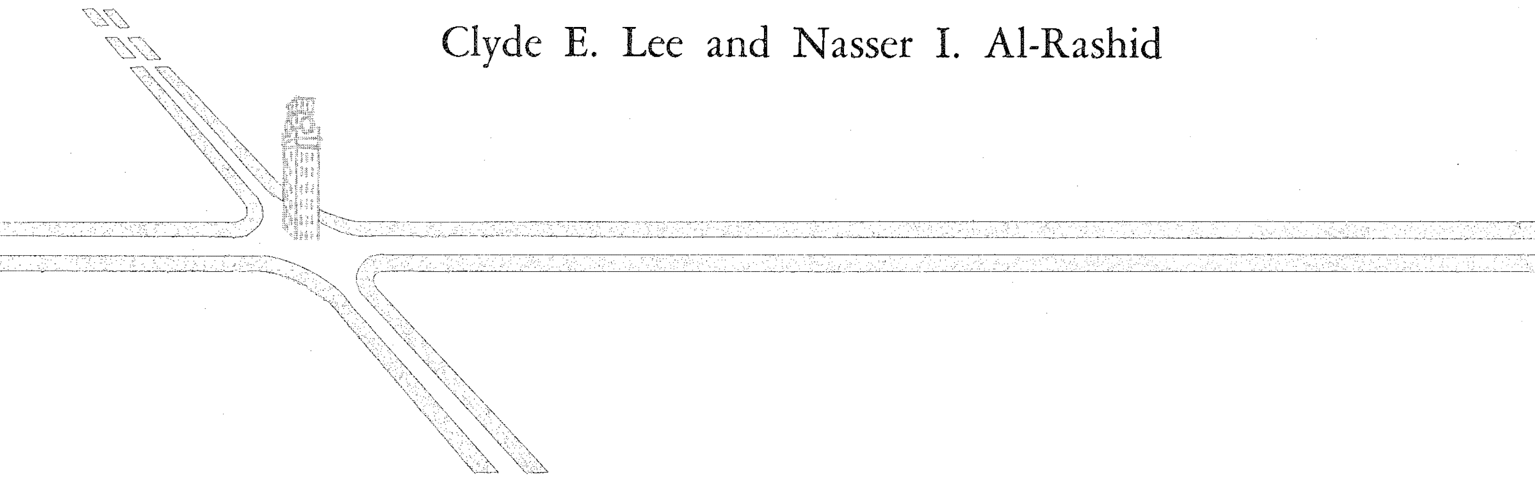
A PORTABLE ELECTRONIC SCALE FOR WEIGHING VEHICLES IN MOTION

By

Clyde E. Lee and Nasser I. Al-Rashid



SUMMARY REPORT 54-1F(S)

SUMMARY OF

RESEARCH REPORT 54-1F PROJECT 3-10-63-54

COOPERATIVE HIGHWAY RESEARCH PROGRAM

WITH TEXAS HIGHWAY DEPARTMENT

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SUMMARY REPORT 54-1F (S)

Foreword

The development of a transportable electronic system for weighing and dimensioning moving highway vehicles is described in Research Report 54-1F. This is the final report for Research Study 3-10-63-54, conducted by the Center for Highway Research at The University of Texas at Austin, in cooperation with the Texas Highway Department and the Bureau of Public Roads. The report describes a new wheel load transducer, the associated electronic instrumentation, and field testing of the assembled system. In addition, it includes documented computer programs for data reduction and an analysis of representative data that indicates the order of precision attainable with the system.

Introduction

The concept of weighing vehicles in motion is not new. Attempts at developing in-motion weighing systems were begun by a number of investigators in this country and in Europe as early as 1950. As a result of their efforts, several scales have been developed, but certain difficulties such as fixed location, platform translation, and inadequate drainage have hampered completely successful operation. This research study was initiated for the purpose of developing a transportable scale with dynamic response adequate for weighing vehicles moving at speeds up to 70 mph. The design of the scale, besides eliminating the inadequacies characterizing other designs, meets the criteria for a sound and practical in-motion system including: portability and fast installation, good compliance, insensitivity to tractive forces, sensitivity to normal forces regardless of load placement, ruggedness and reliability, deflection similar to the normal pavement, and reasonable cost.

Wheel Load Transducers

The wheel load transducer is the load sensing element of the in-motion weighing system. Its function is to detect the component of wheel force acting normal to the pavement surface and convert this force into a corresponding electrical signal. The size, sensitivity, ruggedness, and compliance of the transducer in producing electrical signals that faithfully represent the applied forces are the major factors that were considered in the design.

The first portable wheel load transducer was designed for this study in the summer of 1963 and fabricated in the shops of The University of Texas at Austin and the Texas Highway Department. Two additional transducers of this design were produced by Philco Corporation and delivered with a recording instrument system to the Texas Highway Department in July 1966. After more than two years of field testing, several improvements and modifications were effected in the transducer design, and two new models have been constructed by Rainhart Company in Austin, Texas. Detailed descriptions of the original and the improved designs are included in the study report, but only the most recent design (Rainhart Model 880) is described in this Summary Report. Figure 1 shows the basic features and dimensions of this unit which are: (1) the frame and bearing pads which serve as a skeleton and load-transfer element for the transducer, (2) the load-cell chassis which is a thin aluminum

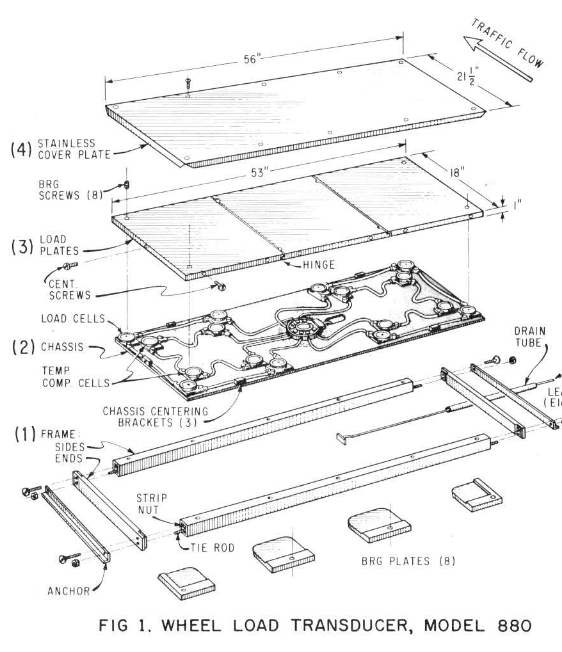

FIG 1. WHEEL LOAD TRANSDUCER, MODEL 880

sheet with eight specially-designed load cells fixed to it and connected with eight temperature-compensating cells such that a full Wheatstone bridge is formed with four load cells in each of two opposite arms and four temperature-compensating gages in each of the remaining arms, (3) the three structural plates which serve to transfer the applied load to the load cells (leveling screws are provided at each corner of the center plate and at the outer corners of the side plates), and (4) the thin stainless steel cover placed over the transducers. The main advantage of this model over previous designs is ease of installation and maintenance. Only 3 inches of pavement surfacing must be removed, and the heaviest component weighs 90 pounds.

Instrumentation

Electrical signals from the wheel load transducers vary continuously with time as the wheels of a moving vehicle pass over, and are therefore suitable for recording directly in analog form. Since sophisticated analog magnetic tape recorders are commercially available at a reasonable cost, this form of recording was chosen for field use. The analog record can subsequently be displayed for visual inspection and interpretation, or it can be converted to digital form for computer processing when large quantities of data are involved.

Figure 2 shows the portable vehicle data recording system presently in use by the Texas Highway Department. Equipment installed in the traffic lane consists of two pneumatic road tubes, an inductance loop detector, and two wheel load transducers.

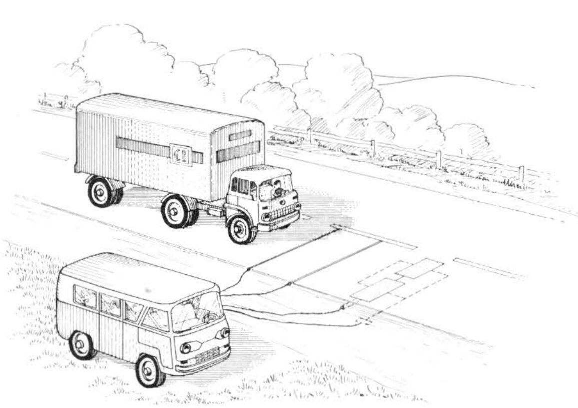

FIG 2. TYPICAL INSTALLATION OF PORTABLE VEHICLE DATA RECORDING SYSTEM

Signals from these sensors (see Fig 3) are recorded on a portable Honeywell 8100, 5-channel FM magnetic tape recorder that is housed along with other electronic equipment in a small van-type vehicle.

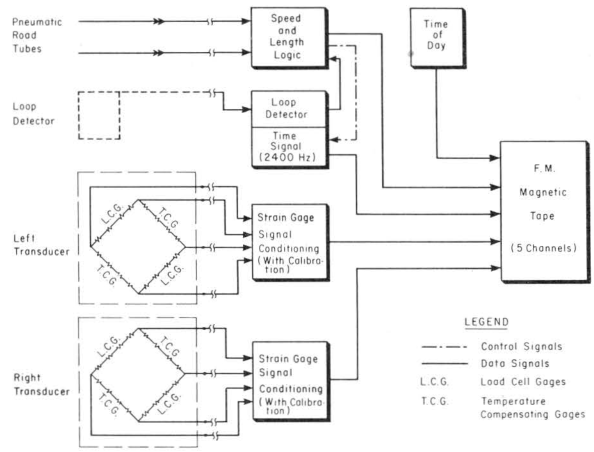

FIG 3. RECORDING LOGIC BLOCK DIAGRAM

Initial installation of all equipment for one-lane operation at a new site requires about 4 hours, but reoccupying a site or replacing a load-cell chassis takes less than 45 minutes. The load-cell chassis and the structural plates can be replaced by dummy units when maintenance is required or when the scales are not in use.

The system is designed to operate unattended for up to 7 days while recording weight, length, axle spacing, and speed information for every vehicle that passes. Selective sampling (e.g. all commercial vehicles) is accomplished by an operator starting the recording system manually as each selected vehicle approaches the instrumented section; the system returns automatically to the standby condition after the vehicle has passed over the scales. Power for the instruments and for the air conditioning units in the instrument van is 115 volts AC supplied by either conventional main line or a portable generator.

Data Processing

Magnetic tapes containing field data are processed at a central computer facility. Special programs for analog-to-digital conversion, data listings, arithmetic manipulation, and tabulation of the data have been developed for the Texas Highway Department system. These programs are

Time of Day	Vehicle Type	Speed, mph	Weight, 100 lbs			No. of Axles	Axle Spacing, ft						Wheelbase, ft	Vehicle Length, ft	Axle 1, 100 lbs			Axle 2, 100 lbs			Axle 3, 100 lbs			Axle 4, 100 lbs			Axle 5, 100 lbs			Axle 6, 100 lbs			Axle 7, 100 lbs		
			Left-Total	Right-Total	Gross										Right Side	Left Side	Total	Right Side	Left Side	Total	Right Side	Left Side	Total	Right Side	Left Side	Total	Right Side	Left Side	Total	Right Side	Left Side	Total	Right Side	Left Side	Total
TIME	VT	VS	LTOT	RTOT	GROS	N	AB	BC	CD	DE	EF	FG	WB	VL	AR	AL	A	BR	BL	B	CR	CL	C	DR	DL	D	ER	EL	E	FR	FL	F	GR	GL	G
20236	22	39	239	246	485	4	11	26	4	0	0	0	41	52	44	43	87	89	85	174	58	56	114	55	54	110	0	0	0	0	0	0	0	0	0
20254	14	57	70	70	140	3	10	4	0	0	0	0	14	19	36	36	72	16	13	29	18	21	39	0	0	0	0	0	0	0	0	0	0	0	0
20336	13	51	31	37	68	2	12	0	0	0	0	0	12	23	17	15	32	20	16	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20448	13	43	39	36	75	2	12	0	0	0	0	0	12	22	16	17	33	20	22	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20830	13	55	24	19	42	2	10	0	0	0	0	0	10	20	11	13	23	8	11	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20900	13	52	29	25	54	2	10	0	0	0	0	0	10	22	12	14	27	13	15	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20036	24	42	141	173	314	5	14	4	32	4	0	0	55	66	32	34	66	45	32	78	39	26	65	23	26	49	34	22	56	0	0	0	0	0	0
21048	14	48	85	105	190	3	13	4	0	0	0	0	18	28	35	36	71	42	34	76	28	15	43	0	0	0	0	0	0	0	0	0	0	0	0
21106	13	41	110	99	209	2	13	0	0	0	0	0	13	18	26	28	54	73	82	155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21430	24	48	134	316	450	5	9	4	28	4	0	0	45	51	83	44	127	49	23	72	75	31	106	60	21	81	49	15	64	0	0	0	0	0	0
21624	14	47	159	126	285	3	16	4	0	0	0	0	20	31	37	45	82	40	51	91	49	63	112	0	0	0	0	0	0	0	0	0	0	0	0
21706	13	46	56	54	110	2	11	0	0	0	0	0	11	19	16	17	34	38	39	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21848	22	42	137	141	277	4	12	19	4	0	0	0	36	47	31	39	70	53	55	109	23	14	38	33	29	62	0	0	0	0	0	0	0	0	0

FIG 4. TABULATION OF TYPICAL DATA

described in detail in the report. A typical listing of representative data is shown in Fig 4. These data are also stored in a convenient format on magnetic tape for future reference.

Conclusions

The feasibility of a transportable in-motion vehicle weighing and dimensioning system for traffic survey purposes has been demonstrated.

The static gross weight of about five hundred vehicles was estimated from dynamic wheel force measurements made by the electronic scale system while the vehicles were moving at normal road speed and was found to be within 10 percent of the static weight measured by conventional loadometer techniques. This order of precision seems acceptable for survey purposes since a very large (up to 100 percent) sample can be taken with no delay, inconvenience, or hazard to traffic.

The system has many potential uses in highway planning, design, and operation. Statistical data can be obtained at many different locations without impeding traffic flow; vehicles can be automatically classified according to number of axles, axle configuration, or wheel weight; lane use by various classes of vehicles can be determined; and traffic control schemes based on the characteristics of individual vehicles can be developed. With some modification, the weighing and dimensioning system can aid enforcement by sorting only those vehicles suspected of being overweight into static weighing stations. Imaginative engineers will find many applications for this new tool in highway operations and research.